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(54) **METHOD OF PRODUCING SUBSTANTIALLY WRINKLE-FREE TEXTILE SURFACES**

(57) A method of applying a fabric relaxant to a textile
surface provides a substantially wrinkle-free textile sur-
face. The method includes moistening the textile surface,
applying the fabric relaxant onto the moistened textile

surface, and drying the moistened textile surface using
steam. The fabric relaxant includes a hydrophobic poly-
dimethylsiloxane polymer having at least one positive-
ly-charged functional group.

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a method of laundering to provide a substantially wrinkle-free textile surface. In particular, the present invention relates to a method of laundering to provide a substantially wrinkle-free textile surface without ironing or pressing.

BACKGROUND OF THE INVENTION

[0002] Wrinkles can cause an unacceptable and unprofessional appearance on textile surfaces, including, for example, wearing apparel, flat goods, and other textiles. In the commercial and industrial businesses, including hotels, restaurants, manufacturing, repair, and service organizations, uniforms (e.g. chef coats, uniforms for waitresses, factory workers, automotive shops, etc.) and flatware (e.g. bed sheets, table clothes, etc.) are representative of the business. It is therefore important that the garments worn by the employees and the flatware used in the business are wrinkle-free. Wrinkles often develop on textiles during washing and in subsequent processing and storing. The rigorous process of washing the textiles, particularly in the commercial setting, subjects the textiles to bending and folding. For example, wrinkles may be introduced onto the textiles during the extraction cycle (high speed spin cycle) of a washing process or when the textiles are extracted using a hydraulic press following washing in a continuous batch washer. Even with proper cool down procedures, wrinkles can develop, especially in contained textiles. The wrinkles thus need to be completely removed in the subsequent finishing process.

[0003] In a typical commercial laundry process, the textiles are sent through a series of aqueous baths where they are exposed to various chemicals needed either to clean the textiles or to achieve a desired quality for the garments, such as softness, fresh scent, water repellency, etc.

[0004] After the textiles have been properly cleaned, the textiles go through a finishing process. For example, garments may be sent through a finishing tunnel and flat goods may be sent through some type of finishing equipment such as an ironer. Garments are frequently exposed to steam and hot air in the finishing tunnel where the steam and hot air function to dry and condition the garments.

[0005] The most common methods of removing wrinkles from garments containing cotton include ironing or pressing the textile. In some applications, the textiles are partially dried ('conditioned') before a final ironing or pressing step. Ironing or pressing the textiles is accomplished by manually inserting the textile into the processing unit, or in the case of garments, manually placing them on hangers. The textiles are then processed through equipment known in the art as an ironer or finishing tunnel.

[0006] One problem with ironing or pressing the textiles in order to eliminate the wrinkles in the textile surfaces is that the process is time, labor, energy, and capital intensive. The finishing equipment is expensive and requires a large foot print within the production area. Ironing or pressing is labor intensive because, as stated above, an employee must either manually insert the textiles, or an operator must manually feed or position the textiles within the equipment. In addition, a significant amount of energy is also consumed by the equipment used to remove the wrinkles from the textile surfaces. Because the production rate is typically one half that of standard processing methods due to the individual handling requirement, this process may constitute the bottleneck in the entire laundering process even if capital-intensive, state-of-the-art equipment is utilized.

BRIEF SUMMARY OF THE INVENTION

[0007] In one embodiment, a method of applying a fabric relaxant provides a substantially wrinkle-free textile surface. The method includes moistening the textile surface, applying the fabric relaxant onto the moistened textile surface, and drying the moistened textile surface using steam. The fabric relaxant includes a hydrophobic polydimethylsiloxane polymer having at least one positively-charged functional group.

[0008] In another embodiment, a method of laundering a textile produces a substantially wrinkle-free textile. The method includes applying a hydrophobic, functionalized polydimethylsiloxane polymer having a positively-charged functional group to the textile and drying the textile surface by steam drying. The textile exhibits substantially no wrinkles after drying when tested pursuant to AATCC method No. 124-1973.

The invention provides:

1. A method of applying fabric relaxant to a textile surface for providing a substantially wrinkle-free textile surface, the method comprising:

- (a) moistening the textile surface;

- (b) applying the fabric relaxant onto the moistened textile surface, wherein the fabric relaxant comprises a hydrophobic polydimethylsiloxane polymer having at least one positively-charged functional group; and
- (c) drying the moistened textile surface using steam.

- 5 2. The method of aspect 1, wherein applying the fabric relaxant comprises applying the fabric relaxant in the form of an aqueous-based carrier or a solvent-based carrier.
3. The method of aspect 1, wherein the fabric relaxant further comprises at least one alkoxy group.
- 10 4. The method of aspect 1, wherein at least one of the positively-charged functional groups is an ammonium group.
5. The method of aspect 4, wherein at least one of the positively-charged functional groups is a quaternary ammonium group.
- 15 6. The method of aspect 1, wherein the polydimethylsiloxane polymer comprises at least one positively-charged functional group at an end of the polydimethylsiloxane polymer.
7. The method of aspect 1, wherein at least one positively-charged functional group is a part of a backbone of the polydimethylsiloxane polymer.
- 20 8. The method of aspect 1, wherein at least one positively-charged functional group is a part of a side chain of the polydimethylsiloxane polymer.
9. The method of aspect 1, wherein the polydimethylsiloxane polymer having a positively-charged functional group is at least one of the groups consisting of: polyfunctional polydimethylsiloxane, polydimethylsiloxane diquaternary ammonium, and polyquaternary polydimethylsiloxane copolyol.
- 25 10. The method of aspect 1, and further comprising:
 - 30 (d) adding a souring agent to the textile surface to lower a pH of the textile surface.
11. The method of aspect 10, wherein the souring agent is selected from at least one of the groups consisting of: formic acid, acetic acid, hydrofluorosilicic acid, citric acid, and phosphoric acid.
- 35 12. The method of aspect 1, and further comprising:
 - (e) adding a fabric softener to the textile surface.
13. The method of aspect 1, and further comprising:
 - 40 (f) conditioning the textile surface prior to drying the moistened textile surface using steam.
14. The method of aspect 1, wherein drying the textile surface comprises drying the textile surface at a temperature of between about 60 degrees Fahrenheit and about 280 degrees Fahrenheit.
- 45 15. The method of aspect 14, wherein drying the textile surface comprises drying the textile surface at a temperature of between about 260 degrees Fahrenheit and about 280 degrees Fahrenheit.
16. The method of aspect 1, wherein applying the fabric relaxant to the textile surface comprises exposing the textile surface to the fabric relaxant for at least about 4 minutes.
- 50 17. The method of aspect 1, wherein the textile surface exhibits substantially no wrinkles after drying when tested pursuant to AATCC method No. 124-1973.
- 55 18. The method of aspect 1, wherein the method is carried out during a finishing cycle of a washing process.
19. A method of laundering a textile to produce a substantially wrinkle-free textile, the method comprising:

- (a) applying a hydrophobic, functionalized polydimethylsiloxane polymer having a positively-charged functional group to the textile; and
 (b) drying the textile by steam drying;
 (c) wherein the textile exhibits substantially no wrinkles after drying when tested pursuant to AATCC method No. 124-1973.

20. The method of aspect 19, wherein applying a hydrophobic, functionalized polydimethylsiloxane polymer having a positively-charged functional group to the textile comprises applying the hydrophobic, functionalized polydimethylsiloxane polymer having a positively-charged functional group in the form of an aqueous-based carrier or a solvent-based carrier.

21. The method of aspect 19, wherein the functionalized polydimethylsiloxane polymer comprises at least one positively-charged functional group at an end of the polydimethylsiloxane polymer.

22. The method of aspect 19, wherein positively-charged functional group comprises an ammonium.

23. The method of aspect 22, wherein positively-charged functional group comprises quaternary ammonium.

24. The method of aspect 19, and further comprising:

- (d) moistening the textile.

25. The method of aspect 19, and further comprising:

- (e) applying a souring agent to the textile.

26. The method of aspect 25, wherein the souring agent is selected from at least one of the groups consisting of: formic acid, acetic acid, hydrofluorosilicic acid, citric acid, and phosphoric acid.

27. The method of aspect 19, and further comprising:

- (f) applying a fabric softener to the textile.

28. The method of aspect 19, wherein drying the textile surface comprises drying at a temperature of between about 60 degrees Fahrenheit and about 280 degrees Fahrenheit.

29. The method of aspect 19, and further comprising:

- (g) conditioning the textile in a dryer prior to drying the textile by steam drying.

30. The method of aspect 19, wherein applying the polydimethylsiloxane polymer to the textile surface comprises exposing the textile to the fabric relaxant for at least about 4 minutes.

31. The method of aspect 19, wherein applying the polydimethylsiloxane polymer to the textile surface comprises spraying the polydimethylsiloxane polymer onto the textile.

32. The method of aspect 19, wherein the method is carried out in a washing machine.

33. The method of aspect 32, wherein the method is carried out during a finishing cycle of the washing machine.

DETAILED DESCRIPTION

[0009] A no-ironing/no-pressing, substantially wrinkle-free method of laundering textiles involves a multi-step washing process during which a fabric relaxant is applied to the textile surface at least once, followed by a drying process employing a steam tunnel. The method may be employed in any of a wide variety of situations where it is desirable to obtain a substantially wrinkle-free textile surface. The method is particularly useful for obtaining a substantially wrinkle-free textile surface without ironing or pressing the textile surface. In addition, the method does not require continuous supervision by an operator or a substantial amount of time to be effective. Examples of textiles that can be relaxed by

a fabric relaxant followed by steam drying such that there is a minimal presence of wrinkles on the textile surfaces include, but are not limited to: clothing and flat goods.

[0010] During the washing step, the textile is first moistened by an aqueous carrier solution, such as water. While the aqueous carrier solution includes water, the aqueous carrier solution may also include other chemicals, including, but not limited to: detergents, alkali, solvent boosters, chlorine or peroxygen based bleaches, fabric softeners, disinfecting agents, sanitizing agents, fragrances, odor-capturing agents, insect repellency agents, anti-pilling agents, mildew removing agents, allergicide agents, soil shielding/soil releasing agents, ultraviolet light protection agents, water repellency agents, moisturizing agents, fiber protection agents, optical brightening agents, anti-static agents, dye transfer inhibition/color-protective agents, starching agents, anti-wrinkle agents, or other chemicals that affect the surface properties of the textiles. The aqueous carrier solution may be applied by any means known in the art, including, but not limited to: soaking, submerging, or spraying. A fabric relaxant may also be applied to the textiles at any of the washing or rinsing processes.

[0011] The aqueous carrier solution, when it includes an anti-static agent, can generate a percent static reduction of at least about 50% when compared with a textile that is not subjected to treatment. The percent static reduction can be greater than 70% and it can be greater than 80%. The aqueous carrier solution can include anti-static agents such as those commonly used in the laundry drying industry to provide anti-static properties. An example of an anti-static agent includes, but is not limited to, an agent containing quaternary groups.

[0012] The aqueous carrier solution can include anti-wrinkling agents to provide anti-wrinkling properties. Examples of anti-wrinkling suitable agents include, but are not limited to: siloxane or silicone containing compounds and quaternary ammonium compounds. Particularly suitable examples of anti-wrinkling agents include, but are not limited to: polydimethylsiloxane diquaternary ammonium, silicone copolyol fatty quaternary ammonium, and polydimethyl siloxane with polyoxyalkylenes. Examples of commercially available anti-wrinkling agents include, but are not limited to: Rewoquat SQ24, available from Degussa/Goldschmidt Chemical Corporation, Hopewell, VA; Lube SCI-Q, available from Lambert Technologies; and Tinotex CMA, available from Ciba Specialty Chemicals Corporation, Greensboro, NC.

[0013] The aqueous carrier solution can include odor capturing agents. In general, odor capturing agents are believed to function by capturing or enclosing certain molecules that provide an odor. Examples of suitable odor capturing agents include, but are not limited to: cyclodextrins and zinc ricinoleate.

[0014] The aqueous carrier solution can include fiber protection agents that coat the fibers of the textile to reduce or prevent disintegration and/or degradation of the fibers. An example of a fiber protection agent includes, but is not limited to, cellulosic polymers.

[0015] The aqueous carrier solution can include color protection agents for coating the fibers of the textile to reduce the tendency of dyes to escape the textile into water. Examples of suitable color protection agents include, but are not limited to: quaternary ammonium compounds and surfactants. Examples of particularly suitable color protection agents include, but are not limited to: di-(nortallow carboxyethyl) hydroxyethyl methyl ammonium methylsulfate and cationic polymers. Examples of commercially available surfactant color protection agents include, but are not limited to: Varisoft WE 21 CP and Varisoft CCS-1, available from Degussa/Goldschmidt Chemical Corporation, Hopewell, VA; Tinofix CL from Ciba Specialty Chemicals Corporation, Greensboro, NC; Color Care Additive DFC 9, Thiotan TR, Nylofixan P-Liquid, Polymer VRN, Cartaretin F-4, and Cartaretin F-23, available from Clariant Corporation, Charlotte, NC; EXP 3973 Polymer, available from Alcoa, Pittsburgh, PA; and Coltide, available from Croda, Edison NJ.

[0016] The aqueous carrier solution can include soil releasing agents that can be provided for coating the fibers of textiles to reduce the tendency of soils to attach to the fibers. Examples of suitable commercially available soil releasing agents include, but are not limited to: polymers such as Repel-O-Tex SRP6 and Repel-O-Tex PF594, available from Rhodia, Cranbury, NJ; TexaCare 100 and TexaCare 240, available from Clariant Corporation, Charlotte, NC; and Sokalan HP22, available from BASF Corporation, Florham Park, NJ.

[0017] The aqueous carrier solution can include optical brightening agents that impart fluorescing compounds to the textiles. In general, fluorescing compounds have a tendency to provide a bluish tint that can be perceived as imparting a brighter color to fabric. Examples of suitable optical brighteners include, but are not limited to: stilbene derivatives, biphenyl derivatives, and coumarin derivatives. Examples of particularly suitable optical brightening agents include, but are not limited to: distyryl biphenyl disulfonic acid sodium salt, cyanuric chloride/diaminostilbene disulfonic acid sodium salt, and diethylamino coumarin. Examples of suitable commercially available optical brightening agents include, but are not limited to: Tinopal 5 BM-GX, Tinopal CBS-CL, Tinopal CBS-X, and Tinopal AMS-GX, available from Ciba Specialty Chemicals Corporation, Greensboro, NC.

[0018] The aqueous carrier solution can include a UV protection agent to provide the fabric with enhanced UV protection. In the case of clothing, it is believed that by applying UV protection agents to the clothing, it is possible to reduce the harmful effects of ultraviolet radiation on skin provided underneath the clothing. As clothing becomes lighter in weight, UV light has a greater tendency to penetrate the clothing and the skin underneath the clothing may become sunburned. An example of a suitable commercially available UV protection agent includes, but is not limited to, Tinosorb FD, available from Ciba Specialty Chemicals Corporation, Greensboro, NC.

[0019] The aqueous carrier solution can include an anti-pilling agent that acts on portions of the fiber that stick out or away from the fiber. Anti-pilling agents can be available as enzymes such as cellulase enzymes. Examples of commercially available anti-pilling agents include, but are not limited to: Puradex, available from Genencor; and Endolase and Carezyme, available from Novozyme, Franklinton, NC.

[0020] The aqueous carrier solution can include water repellency agents that can be applied to textile to enhance water repellent properties. Examples of suitable water repellency agents include, but are not limited to: perfluoroacrylate copolymers, hydrocarbon waxes, and polysiloxanes.

[0021] The aqueous carrier solution can include disinfecting and/or sanitizing agents. Examples of suitable sanitizing and/or disinfecting agents include, but are not limited to: quaternary ammonium compounds such as alkyl dimethylbenzyl ammonium chloride, alkyl dimethylethylbenzyl ammonium chloride, octyl decyldimethyl ammonium chloride, dioctyl dimethyl ammonium chloride, and didecyl dimethyl ammonium chloride.

[0022] The aqueous carrier solution can include insect repellents such as mosquito repellents. An example of a commercially available insect repellent is DEET. In addition, the aqueous carrier solution can include mildewcides that kill mildew and allergicides that reduce the allergic potential present on certain textiles and/or provide germ proofing properties.

[0023] In general, a series of rinse steps follow the washing step during which other chemicals may be applied to the fabric, including, but not limited to: souring agents, softening agents, disinfectants, sanitizers, fragrances, odor-capturing agents, insect repellants, water repellants, sunscreen, moisturizers, anti-static agents, color-protective agents, starching agents, and fabric relaxants. These chemicals may either be applied in separate subsequent rinse baths, in partially combined baths, or in a single bath. The chemicals may also be dispensed as separate products or as combination product, such as a product containing both souring agents and softening agents or a product containing souring agents, softening agents, and fabric relaxants. The chemicals may be dispensed simultaneously or sequentially into the same bath by employing micro-processor controlled pump systems or other dispensing methods.

[0024] For example, at some point during the multiple rinse processes of the washing operation, generally in the final conditioning bath (following several other rinse steps with only water), a souring agent may be added to the textile such that the pH of the textile approximately matches the proper processing pH. The souring agent is a mild acid used to neutralize residual alkalines and reduce the pH of the textile such that when the garments come into contact with human skin, the textile does not irritate the skin. Examples of suitable souring agents include, but are not limited to: phosphoric acid, formic acid, acetic acid, hydrofluorosilicic acid, saturated fatty acids, dicarboxylic acids, tricarboxylic acids, and any combination thereof. Examples of saturated fatty acids include, but are not limited to: those having 10 or more carbon atoms such as palmitic acid, stearic acid, and arachidic acid (C20). Examples of dicarboxylic acids include, but are not limited to: oxalic acid, tartaric acid, glutaric acid, succinic acid, adipic acid, and sulfamic acid. Examples of tricarboxylic acids include, but are not limited to: citric acid and tricarballic acids. In one embodiment, approximately 12 milliliters of souring agent is added to approximately 22 pounds of textiles. In general, the dosage of such souring agents will depend on the concentration of the active ingredient (i.e. the acid) and the amount of alkaline chemicals (such as caustic soda, soda ash, silicates, etc.) added to the previous wash baths which may generate pH values higher than 12. Examples of suitable commercially available souring agents include, but are not limited to: TurboLizer, Injection Sour, TurboPlex, AdvaCare 120 Sour, AdvaCare 120 Sanitizing Sour, CarboBrite, and Econo Sour, all available from Ecolab Incorporated, Saint Paul, MN.

[0025] At another stage, either with or subsequent to the addition of the souring agent, a fabric relaxant may be applied to the textile surface. Preferably, the fabric relaxant is added during the final rinse cycle of the wash process to ensure that the fabric relaxant is neither washed nor rinsed off during subsequent rinsing steps. In addition, the fabric relaxant may be added to the textile either once or numerous times during the wash process. The fabric relaxant is typically applied in either an aqueous-based carrier or a solvent-based carrier. In one embodiment, approximately 15 milliliters of fabric relaxant is added to approximately 22 pounds of textiles. An example of a suitable fabric relaxant is a functionalized polydimethylsiloxane polymer. In general, the polydimethylsiloxane polymer features one or more positively-charged functional group (e.g. quaternary ammonium) to anchor the polydimethylsiloxane polymer to the textile in order to enhance the antiwrinkle performance of the polydimethylsiloxane polymer as compared to other uncharged polydimethylsiloxane polymers. The positively-charged functional group may be part of the backbone of the polydimethylsiloxane polymer or part of a side chain of the polymer. The positively-charged functional group is preferably attached at an end of the polydimethylsiloxane polymer such that the positively-charged group is more accessible. It is also believed that the hydrophobicity of the fabric relaxant also affects the smoothness of the textile. The hydrophobicity of the fabric relaxant is significant because it allows deposition of a chemical out of an aqueous solution onto the textile surface. The more hydrophobic a chemical is, the easier it is to precipitate out, or drive out, the chemical from an aqueous solution. Thus, the presence of molecules having mostly dimethylsiloxane backbones are desired in the fabric relaxant because of the hydrophobic nature of methyl groups. Particularly suitable examples of fabric relaxants include, but are not limited to: polyfunctional polydimethylsiloxane, polydimethylsiloxane diquaternary ammonium, and polyquaternary polydimethylsiloxane copolyol derivatives. Examples of suitable commercially available fabric relaxants include, but are not limited

to: Tegopren 6922 (a.k.a. Rewoquat SQ1), available from Degussa/Goldschmidt Chemical Corporation, Hopewell, VA; Tinotex CMA, available from Ciba Specialty Chemicals Corporation, Greensboro, NC; and Formasil 888, available from GE Silicones, Wilton, CT.

[0026] The polydimethylsiloxane polymer having a positively-charged functional group may also include at least one alkoxy group. Examples of alkoxy groups include, but are not limited to: ethoxy, propoxy, butoxy, and longer alkoxy groups.

[0027] Because the fabric relaxant is preferably added during the final rinse cycle of the wash process, the fabric relaxant will be substantially free of chemicals such as, but not limited to: surfactants, bleaches, and builders. Surfactants, bleaches, and builders need to be rinsed from the textile surface prior to being used due to their detrimental effect on the textile surface when left on the textile surface for an extended period of time. For example, residual surfactants in the textile surface can cause the textile surface to have a soapy feel and residual bleach can damage the textile surface. Residual builders in the textile surface can increase the pH of the textile surface. As previously mentioned, textiles having a high pH can be a skin irritant. Thus, the fabric relaxant is substantially free of these chemicals in order to avoid their potentially detrimental effects.

[0028] A fabric softener may also be added to the textile either together with the fabric relaxant or in a separate step. In one embodiment, approximately 15 milliliters of fabric softener is added to approximately 22 pounds of textiles. However, the dosage of the fabric softener may vary with the type and the concentration of the active ingredient. An example of a suitable commercially available fabric softener includes, but is not limited to, TurboFresh, available from Ecolab Incorporated, Saint Paul, MN. The process of adding fabric softener and fabric relaxant to the textile is generally carried out in the final wash operation, which lasts from between approximately 4 minutes and approximately 7 minutes. Subsequently, all of the water is extracted from the washer and the textiles are removed from the washer for further finishing/drying procedures.

[0029] Before drying the textile, the textile may optionally be conditioned in a dryer. For example, the textile may be placed in a dryer for a short period of time to eliminate some of the water absorbed into the textile during the washing and rinsing processes. Although the textile is discussed as being conditioned in a dryer, the textile may be conditioned by any method known in the art without departing from the intended scope of the present invention.

[0030] In one embodiment, the final step of the laundering process is steam drying of the textile by sending the textile through a steam tunnel. The length of time the textile spends within the steam tunnel depends on a variety of factors, including, but not limited to: the length of the steam tunnel, the mechanical condition of the steam tunnel, and the available steam. In an exemplary embodiment, the textiles are exposed within the steam tunnel for between approximately 4 minutes and approximately 8 minutes. As the textile leaves the steam tunnel, the surface of the textile will be substantially wrinkle-free, as determined by applying American Association of Textile Chemists and Colorists (AATCC) Test Method No. 124-1973. Thus, the textile does not need to be ironed or pressed to achieve a generally smooth appearance. Examples of suitable commercially available steam tunnels include, but are not limited to: SkinnyMac, UMac, MidMac, and CFS 2100, available from Colmac Industries, Inc., Colville, WA. Although the textile is described as being dried by passing through a steam tunnel, the textile can be dried by other methods known in the art, including, but not limited to: heat drying and blow drying. A suitable temperature for drying the textile is between approximately 60 degrees Fahrenheit (°F) and approximately 280 °F. A particularly suitable temperature for drying the textile is between approximately 260 °F and approximately 280 °F.

EXAMPLES

[0031] The present invention is more particularly described in the following examples that are intended as illustrations only, since numerous modifications and variations within the scope of the present invention will be apparent to those skilled in the art. Unless otherwise noted, all parts, percentages, and ratios reported in the following examples are on a weight basis, and all reagents used in the examples were obtained, or are available, from the chemical suppliers described below, or may be synthesized by conventional techniques.

[0032] The following test method was used to characterize the smoothness appearance results in the examples:

AATCC Test Method 124-1973

[0033] Approximately 22 pounds of 100% cotton shirts and pants were washed with cleaning detergent. Approximately 12 milliliters (ml) of souring agent, TurboLizer, was added to a first chemical supply hopper. After the souring agent was added, approximately 15 ml of the fabric relaxant was then added to a second chemical supply hopper. Approximately 15 ml of fabric softener, TurboFresh, was then added to a third supply hopper. The textiles were kept in this bath containing all three chemicals for approximately 4 minutes. Subsequently, the shirts and pants were removed from the washer and placed in a plastic box with 2 one-gallon water bottles on top as weight. After approximately 30 minutes, the shirts and pants were removed from the plastic box, hung on wire hangers, and either air dried or sent through a steam tunnel. The shirts and pants were then subjected to inspection using standard lighting and viewing area by rating

the smoothness appearance of the textile in comparison to reference standards. Four different smoothness ratings were used: unacceptable, very weak, acceptable, and superior.

Materials Used

[0034]

TurboCharge II and TurboFlex D: a textile detergent system, available from Ecolab Incorporated, Saint Paul, MN.
 TurboLizer®: a souring agent, available from Ecolab Incorporated, Saint Paul, MN.
 Tegopren 6922®: a fabric relaxant, available from Degussa/Goldschmidt Chemical Corporation, Hopewell, VA.
 Tintotex CMA®: a fabric relaxant, available from Ciba Specialty Chemicals Corporation, Greensboro, NC.
 Formasil 888: a fabric relaxant, available from GE Silicones, Wilton, CT.
 FC201: a fabric relaxant, available from Wacker Silicones, Adrian, MI.
 CSI-Q2: a fabric relaxant, available from Lambent Technologies, Gurnee, IL.
 Rhodorsil Hydrossoft®: a fabric relaxant, available from Rhodia, Cranbury, NJ.
 TurboFresh®: a fabric softener, available from Ecolab Incorporated, Saint Paul, MN.

Examples 1, 2, and 3 and Comparative Examples A, B, and C

[0035] The fabric relaxants used in Examples 1, 2, and 3 included a functionalized polydimethylsiloxane polymer having at least one positively-charged functional group as the fabric relaxant during the washing process. By contrast, the fabric relaxants of Comparative Examples A, B, and C used various other polymers.

[0036] Approximately twenty-two pounds of textiles were placed in a wash with approximately 12 milliliters (ml) of souring agent, 15 ml of fabric relaxant, and 15 ml of fabric softener. The textiles were hung on wire hangers and passed through a steam tunnel. While in the steam tunnel, the textiles were heated to a temperature of between approximately 260 °F and approximately 280 °F.

[0037] Table 1 provides the fabric relaxant used during the washing process and the smoothness appearance of the textiles after being washed and dried, as analyzed pursuant to the method discussed above, for the compositions of Examples 1, 2, and 3 and Comparative Examples A, B, and C.

Table 1

	Fabric Relaxant	Smoothness Rating
Example 1	Tegopren 6922	Superior
Example 2	Tintotex CMA	Superior
Example 3	Formasil 888	Acceptable
Comparative Example A	FC201	Unacceptable
Comparative Example B	Rhodorsil Hydrossoft	Unacceptable
Comparative Example C	CSI-Q2	Unacceptable

[0038] Examples 1, 2, and 3 and Comparative Examples A, B, and C were tested for the appearance of smoothness, which is illustrated by the data provided in Table 1, after the textiles were washed and passed through a steam tunnel. In particular, the textiles of Examples 1 and 2 had superior smoothness ratings and the textiles of Example 3 had an acceptable smoothness rating. In contrast, the textiles of Comparative Example A, Comparative Example B, and Comparative Example C exhibited unacceptable smoothness appearance ratings.

[0039] As previously mentioned, to achieve a smooth surface, the polydimethylsiloxane polymers must adhere to the textile surface. This may be achieved by exposing the textiles to elevated temperatures in order to crosslink the polymers. Alternatively, because the surfaces of the textiles are generally negatively charged, a positively-charged functional group can assist in anchoring the polydimethylsiloxane polymer to the surface of the textile. The positively-charged functional group, or cationic group, will be attracted to the negatively charged textile and facilitate in adhering the polydimethylsiloxane polymers to the textile surface.

[0040] As can be seen in Table 1, the textiles of Examples 1 and 2 had superior smoothness appearance ratings. It is believed that this is due to the presence of positively-charged functional groups in the polydimethylsiloxane polymer present in the fabric relaxant. In particular, the fabric relaxant of Example 1 contained 50% active polydimethylsiloxane diquatary ammonium and the fabric relaxant of Example 2 contained polyfunctional (cationic/nonionic) polydimeth-

ylsiloxane. In addition, the structure of the fabric relaxant of Example 1 includes a cationic group at each end of the dimethylsiloxane polymer molecule (U.S. Patent No. 4,891,166), making them easily accessible. The structure of the fabric relaxant of Example 1 also includes dimethylsiloxy groups, which are very hydrophobic because of the methyl groups. Generally, molecules that have mostly dimethylsiloxane backbones are more hydrophobic. Hydrophobicity of the fabric relaxant is also important because the more hydrophobic the chemical is, the easier it is to precipitate the chemical out of an aqueous solution. Thus, without being bound by theory, it is believed that both the presence of terminal cationic anchors and the hydrophobicity of the fabric relaxant are important in adhering the polydimethylsiloxane polymers to the textile surface and increasing the smoothness of the textile surfaces.

[0041] The textiles washed using the fabric relaxant of Example 3 had an acceptable smoothness appearance rating, although slightly less acceptable than Examples 1 and 2. While the fabric relaxant of Example 3 also contained a polydimethylsiloxane polymer with at least one positively-charged functional group, the fabric relaxant of Example 3 contained 80% active polyquaternary polydimethylsiloxane copolyol. In addition, it is believed that, due to the copolyol part of the polymer, the fabric relaxant of Example 3 was slightly more hydrophilic than the fabric relaxants of Examples 1 and 2, as measured in terms of solubility and miscibility with water. Thus, it is believed that the textiles washed with the fabric relaxant of Example 3 were not as smooth as the textiles washed with the fabric relaxants of Examples 1 and 2 because of the location of the positively-charged functional groups and the hydrophilic copolyol part of the fabric relaxants.

[0042] The textiles washed with the fabric relaxants of Comparative Examples A, B, and C were observed to have unacceptable smoothness appearances. It is believed that the smoothness appearances of the textiles were affected by the reduced presence, or lack of, at least one positively-charged functional group in the polydimethylsiloxane polymers present in the fabric relaxant as well as the hydrophilicity of the fabric relaxants. Without sufficient numbers of positively-charged functional groups, it is believed that the polydimethylsiloxane polymers were not able to anchor to the textile surfaces strongly enough to be effective. In addition, the more hydrophilic the fabric relaxant, the more difficult it is to precipitate out the chemical from the aqueous solution. Thus, rather than having a smooth appearance, the textiles of Comparative Examples A, B, and C had a stiff and wrinkled appearance.

[0043] Although the fabric relaxants of Comparative Examples A and B included polydimethylsiloxane polymers, the polymers did not have any positively-charged functional groups. In particular, the fabric relaxant of Comparative Example A contained 60% active nonionic polysiloxane. It is also believed that the nonionic polysiloxane was ineffective due to the need for elevated temperatures for cross-linking. The fabric relaxant of Comparative Example B contained 100% amino polydimethyl siloxane, also a nonionic polymer, and did not have much effect on the textiles.

[0044] The fabric relaxant of Comparative Example C did contain some positively-charged functional groups. In particular, the fabric relaxant of Comparative Example C contained 40% of a blend of silicone carboxylate and amino-silicate functional component that is cationic. However, the surface of the textile was still observed as unacceptable after washing and drying. This is believed to be due to the presence of carboxylate groups (silicon carboxylate) in the fabric relaxant. Carboxylate groups are negatively charged (anionic) at neutral pH and are also very hydrophilic. It is believed that the carboxylate groups hinder attachment of the polydimethylsiloxane polymers to the textile surface because the anionic charge of the carboxylate groups eliminates the cationic charge of the positively-charged functional group. Thus, although the fabric relaxant of Comparative Example C did contain at least one positively-charged functional group, its effect was negated by the carboxylate groups. In addition, as mentioned above, it is believed that hydrophobicity, lacking in the fabric relaxant of Comparative Example C, facilitates attachment of polydimethylsiloxane polymers to the textile surface. Thus, in combination with the anionic charge of the carboxylate groups, the hydrophilic nature of the carboxylate groups caused the fabric relaxant of Comparative Example C to perform poorly.

Examples 1, 2, and 3 and Comparative Examples D, E, and F

[0045] The fabric relaxants used in Examples 1, 2, and 3 and Comparative Examples D, E, and F all included a polydimethylsiloxane polymer having at least one positively-charged functional group. In particular, Example 1 and Comparative Example D tested the same fabric relaxant (Tegopren 6922), Example 2 and Comparative Example E tested the same fabric relaxant (Tinotex CMA), and Example 3 and Comparative Example F tested the same fabric relaxant (Formasil 888). Approximately twenty-two pounds of textiles were placed in a wash with approximately 12 milliliters (ml) of souring agent, 15 ml of fabric relaxant, and 15 ml of fabric softener and washed.

[0046] After washing, Examples 1, 2, and 3 were passed through a steam tunnel where the textiles were heated to a temperature of between approximately 260 °F and approximately 280 °F. Comparative Examples D, E, and F were only allowed to air dry for a predetermined amount of time and were not passed through a steam tunnel.

[0047] Table 2 provides the fabric relaxant used during the washing process, the method of drying, and the smoothness appearance of the textiles after being washed and dried, as analyzed pursuant to the method discussed above, for the compositions of Examples 1, 2, and 3 and Comparative Examples D, E, and F.

Table 2

	Fabric Relaxant	Method of Drying	Smoothness Rating
Example 1	Tegopren 6922	Steam Tunnel	Superior
Example 2	Tinotex CMA	Steam Tunnel	Superior
Example 3	Formasil 888	Steam Tunnel	Acceptable
Comparative Example D	Tegopren 6922	Air Drying	Very Weak
Comparative Example E	Tinotex CMA	Air Drying	Very Weak
Comparative Example F	Formasil 888	Air Drying	Very Weak

[0048] After it was determined that the fabric relaxants of Examples 1, 2, and 3 gave superior and acceptable smoothness ratings, the methods of drying the textiles were tested and observed. In particular, Examples 1, 2, and 3 were sent through a steam tunnel while Comparative Examples D, E, and F were only allowed to air dry. As can be seen in Table 2, the textiles that were sent through the steam tunnel exhibited a higher smoothness rating than the textiles that were only allowed to air dry. After being passed through the steam tunnel, Examples 1 and 2 were observed to have superior smoothness ratings and Example 3 was observed to have an acceptable smoothness ratings.

[0049] By contrast, Comparative Examples D, E, and F were only allowed to air dry and received very weak smoothness ratings. This is because in order to achieve a smooth surface, the polydimethylsiloxane polymers must adhere to the textile surface. One method of anchoring the functionalized polydimethylsiloxane polymers to a textile surface is to apply elevated temperatures to the textile surface to crosslink the polymers. The elevated temperatures can be reached by methods such as ironing or pressing the textile surface. However, the ironing and pressing processes are both time-consuming and labor intensive. By passing the textiles through a steam tunnel, the appropriate elevated temperatures may be reached without expending undue time or effort.

[0050] Moistened textiles that are applied with a functionalized polydimethylsiloxane polymer fabric relaxant and subsequently dried in a steam tunnel exhibit improved smoothness appearance. One of the main factors that affects the smoothness appearance level of recently cleaned and dried textiles is the presence of one or more positively-charged functional groups in the polydimethylsiloxane polymers. It is also believed that the hydrophobicity of the fabric relaxant also affects the smoothness of the textile. The presence of a polydimethylsiloxane polymer having at least one positively-charged functional group increases the smoothness appearance of cleaned and dried textiles by facilitating attachment of the polydimethylsiloxane polymer to the textiles. The high hydrophobicity of the fabric relaxant also enhances the smoothness appearance of textiles by efficiently depositing a chemical out of an aqueous solution onto the textile surface. By eliminating the need to iron or press the textiles after cleaning and drying, process times and capital cost for acceptable smoothness appearances of textiles can be decreased.

[0051] Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

Claims

1. A method of applying fabric relaxant to a textile surface for providing a substantially wrinkle-free textile surface, the method comprising:
 - (a) moistening the textile surface;
 - (b) applying the fabric relaxant onto the moistened textile surface, wherein the fabric relaxant comprises a hydrophobic polydimethylsiloxane polymer having at least one positively-charged functional group; and
 - (c) drying the moistened textile surface using steam.
2. The method of claim 1, wherein applying the fabric relaxant comprises applying the fabric relaxant in the form of an aqueous-based carrier or a solvent-based carrier.
3. The method of claim 1, wherein the fabric relaxant further comprises at least one alkoxy group.
4. The method of claim 1, wherein at least one of the positively-charged functional groups is a quaternary ammonium

group.

5. The method of claim 1, wherein the polydimethylsiloxane polymer comprises at least one positively-charged functional group at an end of the polydimethylsiloxane polymer.

6. The method of claim 1, wherein at least one positively-charged functional group is a part of a backbone of the polydimethylsiloxane polymer.

7. The method of claim 1 wherein at least one positively-charged functional group is a part of a side chain of the polydimethylsiloxane polymer.

8. The method of claim 1, wherein the polydimethylsiloxane polymer having a positively-charged functional group is at least one of the groups consisting of: polyfunctional polydimethylsiloxane, polydimethylsiloxane diquaternary ammonium, and polyquaternary polydimethylsiloxane copolyol.

9. The method of claim 1, an further comprising:

(d) adding a souring agent to the textile surface to lower a pH of the textile surface.

10. The method of claim 9, wherein the souring agent is selected from at least one of the groups consisting of: formic acid, acetic acid, hydrofluoro silicic acid, citric acid, and phosphoric acid.

11. The method of claim 1, and further comprising:

(e) adding a fabric softener to the textile surface.

12. The method of claims 1, and further comprising:

(f) conditioning the textile surface prior to drying the moistened textile surface using steam.

13. The method of claim 1, wherein drying the textile surface comprises drying the textile surface at a temperature of between about 60 degrees Fahrenheit and about 280 degrees Fahrenheit.

14. The method of claim 1, wherein applying the fabric relaxant to the textile surface comprising exposing the textile surface to the fabric relaxant for at least about 4 minutes.

15. The method of claim 1, wherein the method is carried out during a finishing cycle of a washing process.



EUROPEAN SEARCH REPORT

Application Number
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