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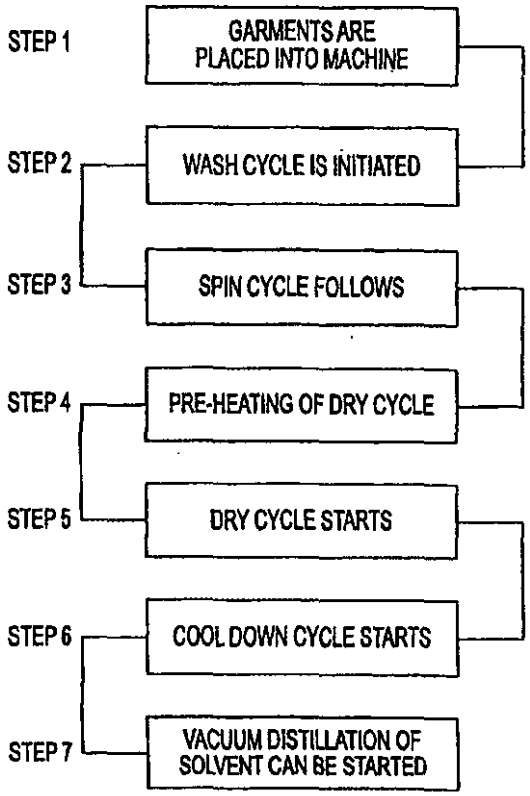
(57) Abstract

A dry cleaning system and method comprises dry cleaning machinery used in conjunction with a cyclic siloxane solvent. In order to enhance the cleaning capabilities of the cyclic-siloxane-based solvent, such solvent is modified with a chemical that is selected from the group of chemicals including 2-ethylhexyl acetate, esters, alchohols, and ethers.



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DRY CLEANING METHOD AND MODIFIED SOLVENT

FIELD OF THE INVENTION

This invention is in the general field of dry cleaning of clothing, textiles, fabrics and the like, and is more particularly directed to a method and apparatus for dry cleaning fabrics using a modified solvent not heretofore used in dry cleaning.

BACKGROUND OF THE INVENTION

Dry cleaning is a major industry throughout the world. In the United States alone, there are more than forty thousand dry cleaners (many of these have multiple locations). The dry cleaning industry is an essential industry in the present economy. Many articles of clothing (and other items) must be dry cleaned in order to remain clean by removal of body fats and oils, and presentable by preventing shrinking and discoloring.

The most widely used dry cleaning solvent until now has been perchloroethylene (PERC). There are numerous disadvantages to PERC including inherent toxicity and odor.

Another problem in this field is that different fabrics require different handling in the presently used systems in order to prevent damage to the fabrics during the dry cleaning process.

Prior art dry cleaning processes include the use of various solvents with appropriate machinery to accomplish the cleaning. As mentioned earlier, the solvent most widely used has been PERC. PERC has the advantage of being an excellent cleaning solvent, but the disadvantage of being a major health and environmental hazard, i.e., it has been linked to numerous forms of cancer and it is very destructive to ground water and aquatic life. In some areas PERC is prohibited due to these disadvantages. Additionally, in the past, other solvents such as petroleum-based solvents and glycol ethers and esters have been tried and used. These various solvents have been used with mixed cleaning results and problematic fabric/textile compatibility as compared to the results obtained with PERC.

The dry cleaning industry has long depended on petroleum-based solvents and the well-known chlorinated hydrocarbons, perchlorethylene and trichlorethylene, for use in the cleaning of fabrics and articles of clothing. Since the 1940's, PERC was praised as being a synthetic compound that is non-flammable and has great degreasing and cleaning qualities ideal for the dry cleaning industry. Beginning in the 1970's, PERC was found to cause liver cancer in animals. This was an alarming discovery, as dry cleaning waste was placed in landfills and dumpsters at that time, from which it leached into soil and ground water.

Environmental Protection Agency regulations gradually were tightened, culminating in a law that took effect in 1996 that required all dry cleaners to have "dry to dry" cycles, meaning that fabrics and articles of clothing go into the machine dry and come out dry. This required "closed loop" systems that can recapture almost all PERC, liquid or vapor. The process of "cycle" involves placing fabrics or articles of clothing into a specially designed washing machine that can hold 15 to 150 pounds of fabrics or articles of clothing that are visible through a circular window. Prior to being placed into the machine, the fabrics or articles of clothing are checked and treated by local hand spotting for stains. If the fabric is unusual or known to be troublesome, the label is checked to verify that the manufacturer has deemed the item safe for dry cleaning. If not, the stain may be permanent. As an example, a sugar stain may not be seen, but once it is run through the dry cleaning process, it oxidizes and turns brown. If the stain is grease related, water won't help, but PERC will as it solubilizes grease. In fact, the principle reason for dry cleaning certain clothes (which should not be washed in a regular washing machine) is to remove the build up of body oils (known as fatty acids) because they too oxidize and produce rancid nasty smells.

The grease which builds up in the solvent is removed by filter and by distilling the PERC. In other words, the dirty PERC is boiled and vapors are condensed back to a clean liquid. A small amount of detergent, typically 1 to 1.5% by volume of the total mixture, is typically mixed with PERC to help solubilize stains and/or stain residues from pre-spotting.

Before clothes are removed from the machine, the washer becomes a dryer. Hot air is blown through the compartment but, instead of being vented outside, the air stream goes through a condenser that liquefies the PERC vapors and returns them for reuse. After the washing and drying, clothes are steamed and ironed.

The dry cleaning process removes most of the PERC from the clothes, however, a small amount does remain. Different fibers of clothes retain more solvent than others. For example, natural fibers such as cottons, wools and thicker articles such as sleeping bags, down coats and shoulder pads tend to retain more solvent than the lighter articles or synthetic fibers.

Another major problem associated with dry cleaning clothes is the color fastness of the dyes used. PERC is a very aggressive solvent and quite often the dyes used by manufacturers are fugitive within PERC or other dry cleaning solvents. At times the fabric may be labeled dry clean only but the prints or surface dyes are fugitive in solvents leaving the article non-serviceable. When an article is cleaned and has a fugitive dye the article suffers and the other articles will experience redeposition of dye on their surface.

Another problem associated with the dry cleaning of fabrics is the redeposition of water-soluble soils that have been loosened from one fabric or article of clothing, and redeposited onto the same or another fabric or article of clothing being cleaned. Volatile silicone solvents alone, are extremely effective in dissolving fats, oils and other organic soils from garments and keeping them in suspension, but cannot hold water-soluble soils in suspension without the aid of a proper detergent.

The same problems exist for PERC and the hydrocarbon based solvents. Special detergents have been developed to solve the problems of suspension of water-soluble soils in these organic solvents and of the redeposition of these soils from them. Detergents developed for use with PERC are not compatible with volatile silicone solvents.

The only use of a cyclic siloxane composition for cleaning purposes is disclosed in U.S. Patent No. 4,685,930 to Kasprzak. However, the disclosure therein is for spot cleaning applications only. There is no disclosure of immersing articles into the cyclic siloxane nor is there any suggestion of using the cyclic siloxane in a dry cleaning machine. Moreover, there is no suggestion of subjecting such articles to immersion in cyclic siloxane agitating, spinning, partial vacuum and heating in a continuous process to dry clean articles in a bulk process for removing fats, oils, grease and other soils from a large number of textile articles.

SUMMARY OF THE INVENTION

The present invention comprises a dry cleaning system and method, in which dry cleaning machinery is used in conjunction with a specific solvent that is derived from an organic/inorganic hybrid (organo silicone). In this class of organo silicones is a group known as cyclic siloxanes. Such cyclic-siloxane-based solvent allows the system to result in an environmentally friendly process which is, also, more effective in cleaning fabrics and the like than any known prior system. The siloxane composition is employed in a dry cleaning machine to carry out the method of the invention. In order to enhance the cleaning capabilities of the cyclic-siloxane-based solvent, such solvent is modified with a chemical that is selected from the group of chemicals including 2-ethylhexyl acetate, esters, alchohols, and ethers. In a preferred embodiment, the method comprises the steps of loading articles into a cleaning basket; agitating the articles and the modified siloxane composition in which they are immersed; removing most of the modified siloxane composition; centrifuging the articles; and removing the articles from the basket after cooling the articles.

DESCRIPTION OF THE DRAWINGS

The aforementioned advantages of the present invention, as well as additional objects and advantages thereof, will be more fully understood hereinafter as a result of a detailed description of a preferred embodiment when taken in conjunction with the following drawing in which:

Figure 1 is a block diagram of the steps of the process showing one embodiment of the present invention.

DISCLOSURE OF THE INVENTION

The present invention includes a method and apparatus for dry cleaning fabrics using a silicone based solvent which has a desirable flash point rating (over 140 degrees Fahrenheit) and fabric-safe qualities (non-dye pulling and non-shrinkage) together with superior solvency for fatty acids, grease and oils in a dry cleaning process.

The present method of dry cleaning employs a fluid class of cyclic siloxanes commonly used for cosmetics and topical pharmaceuticals. These cyclic siloxanes are more particularly known as octamethyl-cyclotetrasilozane (tetramer), decamethyl-cyclopentasiloxane (pentamer) and dodecamethyl-cyclo-hexasiloxane (heximer).

The solvent of the present invention is thus environmentally friendly, does not deposit and or build up in clothing, is hypoallergenic, and has unique flammability characteristics. In use, the flashpoint and firepoint of the solution are separated by at least 10 degrees Fahrenheit, whereby the solvent is self extinguishing between the flashpoint and the firepoint. Further, the solvent can be heated (over 100 degrees Fahrenheit) without causing harm to fabrics which further improves and speeds up the cleaning process. Finally, the solvent may have a surface tension less than 18 dynes/square centimeter to better penetrate fabric fibers to remove debris to make it easier to remove the solvent from the fabric.

The invention discloses the application of volatile organo silicones as alternative solvents to the common petroleum based aliphatic compounds and the halogenated hydrocarbons. Organosilicones are not found in nature and must be prepared synthetically. The ultimate starting material is sand (silicone dioxide) or other inorganic silicates, which make up 75% of the earth's crust. The organosilicones were first synthesized in 1863 by Firedel and Crafts, who first prepared tetraethyl silane. In the following years, although many other derivatives were synthesized, it was not until the 1940's that widespread interest in organosilicone chemistry emerged.

Silica is a relatively electropositive element that forms polar covalent bonds with carbon and other elements, including the halogens, nitrogen and oxygen. The strength and reactivity of silicone depend on the relative electronegativity of the element to which silicones will be covalently bound. The polysilanes upon controlled hydrolysis readily form the polysiloxanes. These cyclic and linear polymers are commercially known as silicone fluids.

Silicone fluids are non-polar and insoluble in water or the lower alcohols. They are completely miscible in typical aliphatic and aromatic solvents, including the halogenated solvents, but are only partially miscible with the intermediate petroleum fractions such as naphthenes. Silicone fluids are insoluble in the higher hydrocarbons, lube oils, waxes, fatty acids, vegetable oils and animal oils... however, the volatile cyclic silicone fluids (tetramer and pentamer) are somewhat soluble in the higher hydrocarbons.

In fact, the lack of dye-pulling and cross staining by the cyclic siloxanes was unexpectedly discovered through the actual reduction to practice of the said cyclic siloxanes as a dry cleaning solvent in a conventional dry cleaning apparatus. The applicants further experienced that the dye pulling problems associated with the conventional solvents were virtually eliminate which resulted in a significant economic gain to the dry cleaning operator. This gain was measured by the ability of the operator to mix garments and articles of clothing, regardless of color, and thus increase cleaning productivity.

As an option, volatile organo silicones (cyclics) may be used in conjunction with an ester additive, more particularly, 2-ethylhexyl acetate (EHA) , provide the basis for superior solvency and cleaning ability.

In testing the degreasing ability of the volatile cyclic silicone/EHA mixtures it was found that they performed better than the petroleum-based aliphatic solvents and comparable to the level of PERC. PERC is a very good and aggressive solvent as a degreaser, however, it can be an over-kill for the purpose of normal dry cleaning. The principle purpose of dry cleaning is to pull out the soil and smelly fatty acids which accumulate in a garment or piece of clothing during wear. An ideal dry cleaning solvent should not have the strength to pull dyes, melt plastics and alter the color or texture of the material to be cleaned.

The volatile cyclic silicones in conjunction with certain organic esters, ether and alcohols process many unique physical and chemical qualities which conventional solvents cannot match. The preferred mixture of Decamethylpentacyclosiloxane and 2-Ethyl Hexyl Acetate are unique for many reasons and are truly selective degreasing agents which are chemically inert to the dyed fiber of a fabric no matter if it is a synthetic or natural. This means that the dye is not attacked or pulled from the fiber chemically, as it would be with the present solvents.

The uniform molecular weight of the volatile cyclic silicones and ester combinations give them the desired surface tension that is important for cleaning. Another major point of importance is that the volatile cyclic silicone fluid imparts a "Silky, Soft Hand" to virtually all fabric or textiles. This feature is important because PERC removes the oils of natural fibers and result in a harsh feel or texture.

The cyclic molecular structure makes them much more oxidation resistant than petroleum based materials. This makes distillation of a cyclic silicone much more reliable. The cyclic nature also makes the fluid penetrate the clothing fibers more readily, and releases entrapped soils.

The two main volatile cyclic silicones, namely the tetramer and the pentamer have a wide range in freezing points i.e. the freezing point for the tetramer is 53 degrees Fahrenheit and the freezing point for the pentamer is - 40 degrees Fahrenheit... nearly 100 degrees Fahrenheit apart. Each of these materials has unique physical properties which by themselves do not make them a viable degreasing solvent for use in a dry cleaning process. For example, the flashpoint of the tetramer is 140 degrees Fahrenheit but its firepoint is 169 degrees Fahrenheit, the flashpoint of the pentamer is 170 to 190 degrees Fahrenheit but its firepoint is 215 degrees Fahrenheit. Both the tetramer and pentanmer can be mixed together to create the desired composition or formula with the right flammability characteristics as well as its freezing point. The preferred ester additive, 2-Ethyl Hexyl Acetate also has a high flashpoint and an extremely low freezing point.

Therefore, the preferred mixture shall be less than 40% EHA and more than 50% pentamer. This range will allow for the development of solvent compositions which are suitable for most dry cleaning operations. Although, the EHA ester is the preferred material, there are numerous materials from the ester, ether and alcohol families, which may exhibit similar capabilities as

mentioned earlier. The following is a list of chemicals which can be used as a replacement for EHA in the preferred mixture:

Esters

Dibasic Esters
Glycol Ether DPM Acetate
Clycol Ether EB Acetate

Alcohols

2-Ethylhexyl Alcohol
Cyclohexanol
Hexanol

Ethers

Glycol Ether PTB
Glycol Ether DPTB
Glycol Ether DPNP

Although the above represent only a few of the likely additives to the volatile organo cyclic siloxanes, it is the scope of this invention to include those not listed.

It should also be noted that certain additives such as petroleum based derivatives i.e. mineral spirits, halogenated hydrocarbons may be added to the above formulary to attain certain cleaning and/or degreasing results which may not be achievable solely by the above composition.

The following lists various materials compositions relative to the above:

Composition -1:
Tetramer - 75% by weight
EHA - 25% by weight

Composition - 2:
EHA - 50% by weight
Pentamer - 50% by weight

Composition - 3:
EHA - 30% by weight
Pentamer - 70% by weight

Composition - 4:
Tetramer - 15% by weight
Pentamer - 55% by weight
EHA - 30% by weight

Composition - 5:
EHA - 85% by weight
Pentamer - 15% by weight

Although the above compositions are mainly based on the volatile organo cyclic siloxanes and EHA, it is within the scope of this invention that the following ranges of composition mixtures are contemplated:
EHA - 1% to 99% by weight
Pentamer - 1% to 99% by weight
Tetramer - 1% to 99% by weight

Combinations of the aforementioned solvents or by themselves may be modified and enhanced in one embodiment of the dry cleaning method of the present invention. The modification is in the form of adding soil suspending additives to prevent re-deposition of dirt during the wash and rinse cycle, detergents for water-base stains, and disinfectants for the disinfection of bacteria and other forms of microorganisms which are present in all clothing. It should be noted that the additive may be included as a component of the solvent solution or as a separate agent.

A suitable detergent, compatible with the siloxane solvent hereof, is disclosed herein and forms a part of the invention. The detergent comprises an amphipathic molecular configuration having a highly hydrophobic linear or cyclic organo-silicone backbone with hydrophilic polar side-chain substitutions and comprising a pure organic molecule or mixed organo-silicone molecule having 1 to 300 moles of polar fingers. Such polar fingers may be ionic. Further, ionic surfactants may be employed in conjunction with the solvent.

The design of a preferred detergent formulation for the volatile silicone solvent should have the following molecular characteristics, in whole or in combination with others:

1. An amphipathic molecular configuration that consists of a highly hydrophobic linear or cyclic backbone with hydrophilic polar side-chain substitutions or "fingers" arrayed from the backbone. The backbone may be a pure organic molecule or a mixed organo-silicone molecule.

2. 1-300 moles of polar fingers per molecule.

3. 20% to 90% by weight of polar fingers.

4. Hydrophile: Lipophile Balance (HLB) of 4 to 18.

5. Where the hydrophilic fingers result from substitutions of the hydrophobic backbone through reactions with ethylene oxide and/or propylene oxide to create polyethers.

Examples of such material compositions that use organo-silicate backbones are:

1. Cyclic Organo-silicone products developed by, and currently available from, General Electric Silicones Division, Waterbury, NY and known by their designated product names as:

SF-1288 (Cyclic Organo-silicone backbone; 66% by weight of ethylene oxide polar fingers)

SF-1528 (Cyclic Organo-silicone backbone; 24% by weight of ethylene oxide and propylene oxide polar fingers; dissolved (10% in 90%) in pentamer).

SF-1328 (Organo-silicone backbone; 24% by-weight of ethylene oxide and propylene oxide polar fingers; dissolved (10% in 90%) in a tetramer and pentamer mixture).

SF-1488 (Organo-silicone backbone; 49% by weight of theylene oxide polar fingers).

2. Organo-silicone products developed by and currently available from Dow Corning Corp., Midland MI, and known by their designated product names as:
3225C (Organo-Silicone backbone; ethylene oxide and propylene oxide polar fingers, dissolved in chyclomethicone).

3. A series of linear organic polyethers with ethylene oxide polar fingers developed by Air Products and Chemicals, Inc., Allentown PA and known by their designated product names as:

Surfynol 420 (20% by weight, of ethylene oxide polar fingers).

Surfynol 440 (40% by weight, of ethylene oxide polar fingers).

Surfynol 465 (65% by weight, of ethylene oxide polar fingers).

The preferred detergent is an 80:20 combination of GE SF-1528 and Surfynol 440.

The above categorizes the basis of the preferred detergent for use with volatile silicone solvents.

The principal intent of this disclosure is to address the fact that volatile silicone solvents should have added compatible detergents in order to fulfill the required dry cleaning parameters required by the industry.

Preferred detergent compositions are as follows:

1. SF-1328 (50%-90%, by weight), and Surfynol 420 (50%-10%, by weight)

2. SF-1328 (70%-95%, by weight), and Surfynol 440 (30%-5%, by weight)

3. SF-1328 (60%-95%, by weight), and SF-1488 (40%-5%, by weight)

4. SF-1528 (60%-95%, by weight), and Surfynol 420 (40%-5%, by weight)

5. SF-1528 (70%-95%, by weight), and Surfynol 440 (30%-5%, by weight)

6. SF-1528 (60%-95%, by weight), and SF-1488 (40%-5%, by weight)

7. SF-1528 (50%-85%, by weight), Surfynol 440 (49%-5%, by weight), and SF-1288 (1%-10%, by weight)

8. SF-1528 (50%-70%, by weight), Surfynol 440 (49%-5%, by weight), and SF-1488 (1%-25%, by weight)

It should be noted that the above formulations and materials are merely examples of material composition that will achieve the desired objective, in this case a detergent. Any organic and/or organo-silicone-based detergent such as the numerous aforementioned organic and/or inorganic organo-silicone compounds may be used to achieve the desired result along with any other related detergent which is compatible with the volatile silicone dry cleaning solvents as long as it removes water-soluble soils from fabrics and prevent their redeposition during the following dry cleaning process.

The following steps are more specifically describe the dry cleaning method of the preferred embodiment.

At step 1 garments or other items to be dry cleaned are placed in a vertical combination washer dryer with a horizontally rotating agitating cleaning basket (known to those skilled in the art). The barrel of the basket will have numerous holes or perforations, preferably each hole will be 1/8 to 1/2 inches in diameter. One of the main reasons for these hole sizes, is to take advantage of the low surface tension of this cyclic siloxane to allow the immediate removal of the same during centrifugation.

At step 2 the wash cycle is initiated with the solvent consisting of a combination of the tetramer and pentamer cyclic siloxane. The preferred combination is 80% tetramer and 20% pentamer by weight. In the alternative, the cyclic siloxane solvent may include any of the aforementioned combinations. The additives which modify the above mixture may be added separately just before the washing cycle and need not be part of the solvent composition. The use of these additives, namely detergents and suspending agents, allows the solvent to perform a total garment cleaning process. The solvent and detergent (if used) is pumped from a holding tank into the cleaning basket. The items being cleaned are agitated, such that the mechanical rubbing of the clothes and the penetrating solvent dissolves and loosens dirt, debris and body fats from the fabric fibers, said agitation lasting from 1 to 15 minutes. During the cleaning cycle, the solvent and the detergent mixture (if used) is pumped out of the basket through a "button trap" and then across a filter. The filter system helps to remove the particulate and impurities form the mixture. At times a choice of a "batch" solvent flow may be used wherein the mixture may not be exposed to the filter system, but be pumped from the button trap directly back to the basket. In the alternative, any type of cartridge, discs, flex-tubular, rigid-tubular either individually or in combination. As yet another option, the filtration system further comprises either an additive such as carbon or diatomaceous earth.

At step 3 the items having been cleaned, the mixture is pumped from the basket to the working tank or still and then the articles are centrifuged to remove as much mixture as possible and pump or gravity feed the remaining mixture to its destination. The centrifuging process lasts from 1 to 7 minutes depending on the articles and greater than 350 Revolutions Per Minute (RPM); preferably between 450 to 750 rpm. This operation leaves no more than 2-5%, or typically 3%, solvent residue in the items being cleaned. The higher the rpm, the faster the solvent is removed by the centrifugal force of the spinning basket. The very low surface tension of the solvent maximizes the efficiency of solvent removal via this centrifugal process.

At steps 4 and 5 the garments are tumbled in the basket and heated to a temperature between 110 and 170 degrees Fahrenheit. The temperature is measured as the vapor-laden air exits the cleaning basket at the pre-condensation point. The heating is accomplished by passing pressurized steam through a coil that heats up the air inside the basket through the use of a circulating fan. While this is happening, a partial vacuum can optionally be created inside the machine at negative pressure between 50 and 600 millimeters of mercury (where atmospheric

pressure is 760 mm), thereby reducing the vapor points of said composition such that recovery time can be shortened. During this heating cycle, the solvent mixture is vaporized and carried by circulating air to a refrigerated condensing coil that condenses the vapors to a liquid that is collected out of the main air stream. The air stream may then be heated again in a closed loop-type system. In time, typically 10 to 55 minutes, the solvent mixture is removed from the articles and recovered for reuse.

At step 6 the heating cycle is stopped and the cooling cycle begins. The cooling cycle may take between 1 to 10 minutes. The temperature is reduced from a range of 110 to 170 degrees Fahrenheit to below 100 degrees Fahrenheit, preferably in a range between 70-100 degrees Fahrenheit. This is accomplished by eliminating the heat and circulating the air through the refrigerated coils until the process is complete. The air is simply circulated about the heated coil without steam flowing through the coils. The cleaning process is completed when the garments are removed from the machine at the cooled down temperature to reduce secondary wrinkling. Removing the garments at a high temperature would cause wrinkling.

At step 7 the contaminated siloxane solvent is reprocessed and purified through vacuum distillation by way of the liquid ring pump method or the venturi method with additional fan assist. This is accomplished by pumping the solvent with impurities into a vacuum still whose chamber is evacuated to assist the drying process. Heat is generated through steam energized coils in contact with the chamber in the range of 230 to 300 degrees Fahrenheit.

The cyclic siloxanes have boiling points over 150 degrees Fahrenheit. For example, the tetramer has a boiling point over 175 degrees Fahrenheit and the pentamer has a boiling point over 209 Degrees Fahrenheit. To distill these siloxanes at their normal boiling point without vacuum temperatures can assist the cause of chemical destruction, i.e., the ring structure is broken down to a linear structure over 150 degrees Fahrenheit and result in the formation of formaldehyde. In one embodiment of the present invention, it is economically advantageous that provisions be made to purify and recover the contaminated cyclic siloxane which will keep their cyclic ring structure intact, bringing the reprocessed solvent. Vacuum distilling the contaminated cyclic siloxane solvent(s) eliminates the low boiling point contaminates, including residual water, as well as the high boiling point contaminates.

It has been discovered that the cyclic siloxanes, namely, the tetramer and pentamer will azetrope at a low temperature such as 209 degrees Fahrenheit result in pure water and pure solvent with the solvents' contaminated solubles remaining behind as residue.

While various embodiments have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of a preferred embodiment should not be limited by any of the above described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

CLAIMS

What is claimed is:

1. A method of dry cleaning articles comprising the acts of:
(a) immersing said articles to be dry cleaned in a composition including a siloxane solvent and a chemical selected from the group of chemicals including 2-ethylhexyl acetate, esters, alchohols, and ethers;
(b) agitating said articles in said composition; and
(c) removing said composition from said articles.

2. The method recited in claim 1, wherein said composition comprises a siloxane solvent selected from the group including pentamer, tetramer, and hexamer cyclic siloxanes.

3. The method recited in claim 1, wherein said chemical includes 2-ethylhexyl acetate.

4. The method recited in claim 3, wherein said siloxane solvent includes tetramer cyclic siloxane.

5. The method recited in claim 4, wherein said tetramer cyclic siloxane is 75% by weight and said 2-ethylhexyl acetate is 25% by weight.

6. The method recited in claim 3, wherein said siloxane solvent includes pentamer cyclic siloxane.

7. The method recited in claim 6, wherein said pentamer cyclic siloxane is between 60% and 80% by weight and said 2-ethylhexyl acetate is 20% and 40% by weight.

8. The method recited in claim 6, wherein said pentamer cyclic siloxane is 50% by weight and said 2-ethylhexyl acetate is 50% by weight.

9. The method recited in claim 6, wherein said pentamer cyclic siloxane is 15% by weight and said 2-ethylhexyl acetate is 85% by weight.

10. The method recited in claim 3, wherein said siloxane solvent includes pentamer cyclic siloxane and tetramer cyclic siloxane.

11. The method recited in claim 10, wherein said tetramer cyclic siloxane is 15% by weight, said pentamer cyclic siloxane is 55% by weight and said 2-ethylhexyl acetate is 30% by weight.

12. The method recited in claim 1, wherein said chemical includes an ester selected from the group including dibasic esters, glycol ether DPM acetate, and clycol ether acetate.

13. The method recited in claim 1, wherein said chemical includes an alcohol selected from the group including 2-ethylhexyl alcohol, cyclohexanol, and hexanol.

14. The method recited in claim 1, wherein said chemical includes an ether selected from the group of ethers including glycol ether PTB, glycol ether DPTB, and glycol ether DPNP.

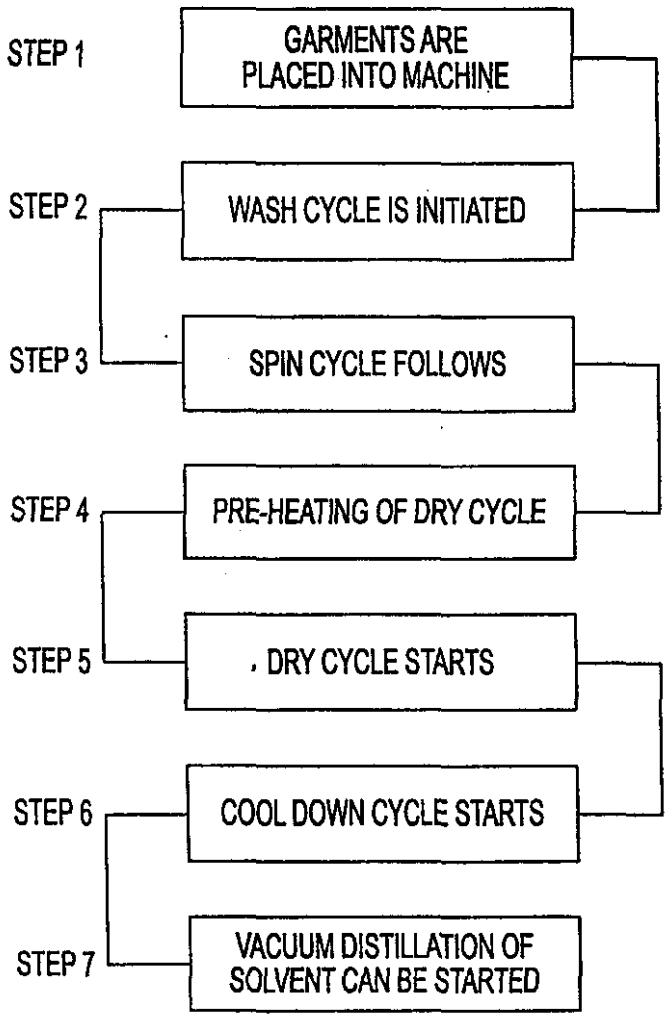
STEP 1
GARMENTS ARE PLACED INTO MACHINE
STEP 2
WASH CYCLE IS INITIATED
STEP 3
SPIN CYCLE FOLLOWS
STEP 4
PRE-HEATING OF DRY CYCLE
STEP 5
DRY CYCLE STARTS
STEP 6
COOL DOWN CYCLE STARTS
STEP 7
VACUUM DISTILLATION OF SOLVENT CAN BE STARTED

FIG. 1

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/US 99/15923

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 D06L1/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 D06L D06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 37 39 711 A (KREUSSLER CHEM FAB) 8 June 1989 (1989-06-08) examples 1,2	1,2,4-11
A	US 4 685 930 A (KASPRZAK KENNETH A) 11 August 1987 (1987-08-11) cited in the application claim 1; example 2	1,2,4-11

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 October 1999	28/10/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Saunders, T

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No
PCT/US 99/15923

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 3739711 A	08-06-1989	NONE	
US 4685930 A	11-08-1987	AU 585906 B	29-06-1989
		AU 4981785 A	22-05-1986
		CA 1239326 A	19-07-1988
		EP 0182583 A	28-05-1986
		JP 1502875 C	28-06-1989
		JP 61119765 A	06-06-1986
		JP 63050463 B	07-10-1988

[19]中华人民共和国国家知识产权局

[51]Int. Cl[7]
D06L 1/02

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[32]1999.5.3 [33]US [31]09/304,430

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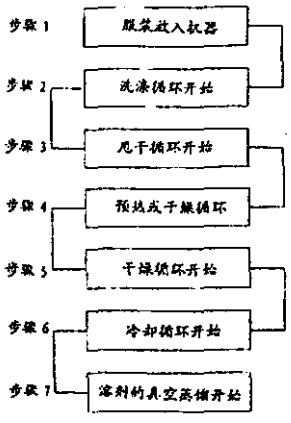
代理人 余 刚

权利要求书2页 说明书14页 附图页数1页

[54]发明名称 干洗方法和改良溶剂

[57]摘要

一种干洗系统和方法,包括干洗机,与环状硅氧烷溶剂结合使 用。为了提高环状硅氧烷基溶剂在洗涤中的性能,所述的溶剂要用 一种化学制品进行改性,该化学制品选自一组包括2-乙基已基醋酸 酯、酯类、醇类和醚类的化合物。



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权 利 要 求 书

1. 一种干洗物品的方法，包括如下操作：
(a)将进行干洗的物品在一种合成物中浸泡，合成物包括一种硅氧烷溶剂和一种化学制品，所述的化学制品选自一组包括2-乙基己基醋酸酯、酯类、醇类和醚类的化合物；
(b)在所述的合成物中搅动所述的物品；并且
(c) 将合成物从所述的物品排除。

2. 权利要求1中所述的方法，表述的合成物包含一种硅氧烷溶剂，选自一组包括五聚物、四聚物和六聚物的环状硅氧烷。

3. 权利要求1中所述的方法，表述的化学制品包含2-乙基己基醋酸酯。

4. 权利要求3中所述的方法，表述的硅氧烷溶剂，包括四聚物环状硅氧烷。

5. 权利要求4中所述的方法，表述的四聚物环状硅氧烷占重量的75%，表述的2-乙基己基醋酸酯占重量的25%。

6. 权利要求3中所述的方法，表述的硅氧烷溶剂，包括五聚物环状硅氧烷。

7. 权利要求6中所述的方法，表述的五聚物环状硅氧烷占重量的60%和80%，表述的2-乙基己基醋酸酯占重量的20%和40%。

8. 权利要求6中所述的方法，表述的五聚物环状硅氧烷占重量的50%.，表述的2-乙基己基醋酸酯占重量的50%。

9. 权利要求 6 中所述的方法，所述的五聚物环状硅氧烷占重量的 15%，所述的 2-乙基己基醋酸酯占重量的 85%。

10. 权利要求 3 中所述的方法，所述的硅氧烷溶剂，包括五聚物环状硅氧烷和四聚物环状硅氧烷。

11. 权利要求 10 中所述的方法，所述的四聚物环状硅氧烷占重量的 15%，所述的五聚物环状硅氧烷占重量的 55%，所述的 2-乙基己基醋酸酯占重量的 30%。

12. 权利要求 1 中所述的方法，所述的化学制品包括一种酯类，选自二盐基酯类，乙二醇醚 DPM 醋酸酯，乙二醇醚 EB 醋酸酯。

13. 权利要求 1 中所述的方法，所述的化学制品包括一种醇类，选自 2-乙基己基醇，环己醇，己二醇。

14. 权利要求 1 中所述的方法，所述的化学制品包括一种醚类，选自乙二醇醚 PTB，乙二醇醚 DPTB，乙二醇醚 DPNP。

说 明 书

干洗方法和改良溶剂

本发明所属技术领域

本发明属于对服装、织物、纺织品等进行干洗的一般领域，是一种更为独特的方法和设备，采用一种以前不曾使用过的改性溶剂进行织物干洗。

与本发明相关的背景技术

干洗是一种遍及世界的重要行业。仅在美国就有 4 万多家干洗店（其中许多有连锁店），干洗是当今经济中不可缺少的行业。许多衣物（及其他物品）必须进行干洗，以除去身体分泌油脂，保持清洁，同时防止缩水及褪色。

迄今为止普遍采用的干洗剂是全氯乙烯（PERC）。它的使用存在着许多不利因素，包括其自身的毒性和气味。

在该领域中存在的另一个问题是不同的织物需要不同的系统，以防止织物在干洗过程中被损坏。

先前的干洗工艺包括使用各式溶剂及适合的机器来完成洗涤。如前所述，过去最普遍采用的溶剂是全氯乙烯。全氯乙烯有着非常好的洗涤效果，但其主要缺陷是危害健康，污染环境。它的使用会

导致许多种癌症，污染地下水，损害水生物。在一些地区，由于其危害性，全氯乙烯被禁用。此外，过去也曾尝试使用其他溶剂，例如石油基溶剂、乙二醇酯、醚类。所述各类溶剂的洗涤效果及与织物的适用，可与全氯乙烯进行类比。

干洗业长期依赖石油基溶剂，及著名的氯化烃、全氯乙烯和三氯乙烯，用来清洗纺织品和服装面料。自二十世纪四十年代以来，全氯乙烯被誉为不易燃，强力去污，洗涤效果理想，特别适用于干洗工业的合成物。在二十世纪七十年代初，发现全氯乙烯可致动物肝癌。这是一个引起恐慌的发现，因为干洗行业的污水排放、废物堆积，会使污染物渗入土壤和地下水。

环境保护机构日益出台更为严格的法规，最终于 1996 年要求所有干洗店采用“干至干”循环，即纺织品及衣物以干燥状态进机，以干燥状态出机。这要求闭环系统操作，以回收绝大部分液态和气态全氯乙烯。此“循环”过程包括，将衣物和织物放入特制的洗衣机，该洗衣机可容纳 15-150 磅织物和衣物，带有圆形可视窗。放入洗衣机前，要对织物或衣物的污渍进行人工检查。如果织物是非常见的，或者是难于处理的质地，则需检查标签，确认制造商是否认为产品适于干洗。如果不这样做，则可能造成永久性污渍。例如，一处糖渍不易被发现，但是一经干洗，就会被氧化而变成棕色。如果污渍是油渍，水就不起作用，而全氯乙烯可以溶解油脂。事实上，对某些衣物采用干洗方法的主要原因（此类衣物不适用常规洗衣机），是除去积聚的身体分泌的油脂（如脂肪酸），因其易于氧化而产生污秽气味。

积聚于溶剂中的油脂被过滤器去除，回收全氯乙烯。换而言之，脏污的全氯乙烯被蒸馏、冷凝成为清洁液体。少量的清洁剂，通常占混合物总体积 1%到 1.5%，典型的是与全氯乙烯混合，以帮助溶解污渍/或预除污渍。

从机中取出衣物前，洗涤机成为干燥机。热风吹入箱体，不再是向外排风，取而代之的是，气流进入冷凝器，液化全氯乙烯蒸汽，进行回收再利用。经过洗涤和干燥，衣物被熨烫平整。

干洗过程已除去衣物中大部分全氯乙烯，但仍有少量残存。有些衣物纤维比其他种类的布料留存的溶剂更多。例如，棉、毛等天然纤维，睡袋等厚重织物，绒毛大衣、垫肩等，就比那些轻薄织物或人造纤维残存溶剂多。

另外一个涉及服装干洗的重要问题，是所用染料着色的牢固度。全氯乙烯是一种颇具侵蚀性的洗涤剂，并且通常服装制造商所用染料易在全氯乙烯或其他干洗溶剂中脱色。有时织物上有只能干洗的标签，但是织物的印花或表面染料却易褪色，不耐用。当某种织物在洗涤过程中褪色，就会造成其他织物着色。

另一个涉及织物干洗的问题，是从衣物或织物上脱落的水溶性脏物的再沉淀，所述的再沉淀物会沉淀到其他被清洗的衣物或织物上。仅就有挥发性的硅树脂类洗涤剂而言，对于溶解衣物上脂肪、油污和其他有机物非常有效，并可保持其悬浮，但在没有合适的清洁助剂帮助下，不能保持水溶性物质悬浮。

对于全氯乙烯及其他烃基溶剂也存在同样问题。已开发特殊的清洁剂，解决水溶性物质悬浮于有机溶剂及从中再沉淀问题。全氯乙烯所用清洁助剂与挥发性硅树脂类洗涤剂所用助剂不同。

唯一将环状硅氧烷组分用于洗涤目的描述，在美国专利4,685,930 号中由 Kasprzak 披露。然而，该披露仅就斑点清洗提出申请。既没有披露在环状硅氧烷中浸泡衣物，也没有任何关于在干洗机中使用环状硅氧烷的建议。此外，没有建议涉及诸如将纺织品浸泡于环状硅氧烷中，搅动，旋转，部分抽真空及加热等连续过程，

以批量方式干燥、清洁衣物，从大量衣物上去除脂肪、油脂和其他污物。

本发明包括一种干洗系统和方法，再本发明中，干洗机与特制溶剂结合使用，所述的溶剂源于一种有机/无机杂化物（有机硅树脂）。在此类有机硅树脂中，有一组已知为环状硅氧烷。这类环状硅氧烷基洗涤剂，使该系统应用对环境保护更为有利，同时，在洗涤织物等方面也较以往系统更为有效。所述的硅氧烷组分被用于干洗机，以贯彻本发明的方法。为提高环状硅氧烷基洗涤剂的洗涤力，所述的溶剂要用一种化学制品进行改性，该化学制品选自一组包括2-乙基己基醋酸酯、酯类、醇类和醚类的化合物。在一个优选实施例中，该流程包括如下步骤：将衣物放置于洗涤筐；搅动衣物，并且衣物被浸泡于改性的硅氧烷组分中；除去绝大部分硅氧烷组分；离心甩干衣物；冷却后，将衣物从筐中取出。

附图简要描述

前述本发明的优点，以及附加的目的和有关优点，通过对下文优选实施例的详细描述，以及结合附图，有助于更好的理解。

图 1 是一个方框图，展示本发明的一个实施例。

发明详述

本发明包括一种方法和干洗设备，用硅氧烷基洗涤剂洗涤织物，其闪点值（超过 140F° ），不损伤织物（不脱色，不收缩），并且在干洗过程中对脂肪酸，油脂有极好的溶解力。

所述的干洗方法，使用一种液体的环状硅氧烷，通常用于化妆品和药剂。以下环状硅氧烷更为独特：八甲基环四硅氧烷（四聚物），十甲基环戊硅氧烷（五聚物），十二甲基环六硅氧烷（六聚物）。

本发明的溶剂对环境无害，不沉淀、积聚于衣物，具有低变应原性，及独特的可燃性。在使用中，溶液的闪点和燃点至少分开有十华氏度，因此该溶剂可在闪点和燃点间自熄。进一步说，该溶剂可被加热（超过 100 华氏度），不会引起织物损伤，进一步提高洗涤速度。最后，所述的溶剂具有小于 18 达因/平方厘米的张力，能够较好穿透织物纤维，去除污渍，并更易于除去织物中残存溶剂。

本发明披露了具挥发性的有机硅树脂，作为常见的石油基脂族化合物和卤化烃的替代溶剂。自然界中不存在有机硅树脂，必须人工制备。最初材料是沙（二氧化硅），或其他无机硅酸盐，这些物质在地壳中占 75%的比例。有机硅树脂是在 1863 年由 Firedel 和 Crafts 首次合成，他们首次制备了四乙基硅烷。在随后几年中，尽管合成了许多其他衍生物，但是，直到二十世纪四十年代，才产生对有机硅树脂化学的广泛兴趣。

硅是一种电正性元素，能够与碳及其他元素，包括卤素、氮、氧等形成共价键。硅树脂的强度与活性取决于形成硅树脂共价键的电负性元素的特性。聚硅烷按一定条件水解处理，形成聚硅氧烷。这些环状和直链聚合物在商业上称为硅树脂液（硅酮液）。

硅酮液是无极性的，不溶于水和低级醇类，完全可溶于典型的脂族和芳香族溶剂，包括卤化溶剂，但是仅可部分溶于如环烷类的石油中间馏分。硅酮液不溶于高级碳氢化合物、润滑油、石蜡、脂肪酸、植物油以及动物油等等。而挥发性的环状硅酮液（四聚物和五聚物）微溶于高级碳氢化合物。

事实上，是在将环状硅氧烷作为干洗剂应用于普通干洗设备时，意外发现使用环状硅氧烷可减少脱色和交互着色。申请人进一步发现事实上消除了常用溶剂引起的脱色问题，从而为干洗商赢得很大的经济利益。此利益表现为，干洗商在混合洗涤中不必考虑衣物颜色，从而大大提高了洗涤生产能力。

作为一种选择，有挥发性的有机硅树脂（环状）可结合使用酯类添加剂，特别推荐 2-乙基己基醋酸酯（EHA），可提供强力溶解和洗涤能力。

在对这种易挥发的环状硅树脂/2-乙基醋酸酯混合物脱脂力测试中，发现其效果优于石油基脂族溶剂，可与全氯乙烯媲美。全氯乙烯是一种很好的深度脱脂剂，但是，对于普通干洗来说其效力过强。干洗的主要目的，是去除衣物在穿着过程中积聚的灰土，及产生异味的脂肪酸。一种理想的干洗剂，不应由于效力过强而使被洗材料脱色，溶解塑料，或改变其颜色、质地。

所述的易挥发的环状硅树脂，与一定的有机酯类，醚类，及醇类结合，会获得许多独特的物理和化学性质，是传统溶剂所不能比拟的。优选的是十甲基环戊硅氧烷，和 2-乙基己基醋酸酯，出于许多原因考虑，其为特别值得选择的脱脂剂，所述的脱脂剂对染色的织物纤维，无论是天然的还是合成的纤维，具有化学惰性。这意味着，所述的溶剂不会象现有溶剂那样，造成混染和脱色问题。

易挥发的环状硅氧烷与酯类化合物的均衡的分子量，赋予其理想的表面张力，这对于洗涤来说非常重要。另一个重要方面是，易挥发的环状硅树脂液事实上赋予所有织物以一种“柔顺，柔软手感”。此特性很重要，因为全氯乙烯会对天然纤维脱脂，使织物手感粗糙。

环状分子结构使其抗氧化能力优于石油基材料。这使得蒸馏环状硅氧烷更为可靠。环状结构使液体渗入衣料纤维更为容易，以除去灰土。

两种主要的环状硅氧烷，即四聚物和五聚物，有很宽的冰点范围，其冰点从四聚物冰点 53 华氏度到五聚物冰点-40 华氏度，有将近 100 华氏度温差。所述的每一种材料具有独特的物理性能，单独使用不适于作干洗脱脂溶剂。例如，四聚物的闪点为 140 华氏度，但其燃点是 169 华氏度，五聚物的闪点为 170-190 华氏度，但其燃点是 215 华氏度。四聚物和五聚物可混合在一起，产生理想的组分或配方，有理想的燃烧特性和冰点。优选的酯类添加剂，是 2-乙基己基醋酸酯，也具有高闪点和极低的冰点。

因此，优选的混合物是少于 40%的 2-乙基己基醋酸酯，和多于 50%的五聚物。此范围适合大多数干洗操作。尽管 2-乙基己基醋酸酯类是优选材料，还可从众多的材料中选用，如酯类、醚类和醇类家族，其具有前述材料相似的性能。下述化合物清单可用于替换优选混合物中的 2-乙基己基醋酸酯:

<u>酯类</u>

二盐基酯类

乙二醇醚 DPM 醋酸酯

乙二醇醚 EB 醋酸酯

<u>醇类</u>

2-乙基己基醇

环己醇

己二醇

醚类

乙二醇醚 PTB

乙二醇醚 DPTB

乙二醇醚 DPNP

尽管以上仅列出有限的易挥发有机环状硅氧烷添加剂，未列出的也在本发明范围内。

应当指出，对以上配方应添加一定的添加剂，如石油基衍生物，即溶剂油类、卤化烃类，以获得一定清洁/或脱脂效果，单独使用以上组分不可能获得所述的效果。

以下所列为上述各种材料组分：

组分 1:

四聚物-占重量 75%

2-乙基己基醋酸酯（EHA）-占重量 25%

组分 2:

2-乙基己基醋酸酯（EHA）-占重量 50%

五聚物-占重量 50%

组分 3:

2-乙基己基醋酸酯（EHA）-占重量 30%

五聚物-占重量 70%

组分 4:

四聚物-占重量 15%

五聚物-占重量 55%

2-乙基己基醋酸酯（EHA）-占重量 30%

组分 5:

2-乙基己基醋酸酯（EHA）-占重量 85%

五聚物-占重量 15%

尽管以上组分主要基于易挥发有机环状硅氧烷和 2-乙基己基醋酸酯（EHA），以下组分化合物也在本发明范围内:

2-乙基己基醋酸酯（EHA）-占重量 1%-99%

五聚物-占重量 1%-99%

四聚物-占重量 1%-99%

与前述溶剂的组合物或其本身，可在本发明一个干洗方法实施例中进行改良或加强。改良形式有：加入沙土悬浮添加剂，防止尘土等脏物在洗涤、漂洗过程中再沉淀；加入水溶性污渍清洗剂；及消毒、灭菌剂，以消灭所有衣物中存在的微生物和细菌。所述添加剂可以是溶剂组分，也可以是独立的制剂。

一种适用的清洁剂，可与硅氧烷溶剂配伍，在此进行披露，构成本发明的一部分。所述的清洁剂由两亲的分子结构组成，具有高度亲油的直链或环状有机硅氧烷主链，及亲水极性侧链，可替代和组成一种纯有机分子，或与有机硅氧烷分子混合，具有 1-300 摩尔极性指状颗粒。所述的极性指状颗粒可以是离子的形式。进一步，离子表面活性剂可与溶剂结合使用。

用于所述的易挥发硅氧烷溶剂的优选清洁剂配方设计，应具有以下分子特性，全部的或与其他组分结合:

1. 一种两亲的分子结构，由高度亲油的直链或环状有机硅氧烷主链组成，有亲水极性侧链的取代，或在主链上有指状颗粒排列。

2. 每个分子具有 1-300 摩尔极性指状颗粒。

3. 极性指状颗粒占重量的 20%-90%。

4. 亲水物：亲脂体配比（HLB）为 4 比 18。

5. 通过与环氧乙烷和/或环氧丙烷反应，产生聚醚，构成脂主链上的亲水指状颗粒取代基。

使用有机硅酸酯主链作材料组分实例如下：

1. 环状有机硅氧烷成品，可由通用电气硅氧烷部获得，纽约，Waterbuary,所知产品名称为：

SF-1288（环状有机硅氧烷主链；占重量 66%的环氧乙烷极性指状颗粒）

SF-1528（环状有机硅氧烷主链，占重量 24%的环氧乙烷和环氧丙烷极性指状颗粒；溶解于（10%于 90%）五聚物中）。

SF-1328（有机硅氧烷主链；占重量 24%的环氧乙烷和环氧丙烷极性指状颗粒；溶解于（10%于 90%）四聚物和五聚物混合物中）。

SF-1488（有机硅氧烷主链；占重量 49%的环氧乙烷极性指状颗粒）。

2. 有机硅氧烷成品可由窦科宁公司获得，公司在 Midland MI，其产品名称为：

3225C（有机硅氧烷主链；环氧乙烷和环氧丙烷极性指状颗粒，溶解于 chyclomethicone）。

3. 一系列直链有机聚醚带环氧乙烷极性指状颗粒，由 Air Products and Chemicals 公司提供，在 Allentown PA，产品名称为：

Surfynol 420（环氧乙烷极性指状颗粒，占重量 20%）。

Surfynol 440（环氧乙烷极性指状颗粒，占重量 40%）。

Surfynol 465（环氧乙烷极性指状颗粒，占重量 65%）。

优选的清洁剂是一种 80:20 配比的 GE SF-1528 和 Surfynol 440。

上述类别是基本的优选清洁剂，与易挥发硅氧烷溶剂配合使用。

此披露意图，是说明易挥发硅氧烷溶剂应与清洁剂配合使用，以满足工业要求的干洗参数。

优选的清洁剂参数如下：

1. SF-1328（占重量的 50%-90%），和 Surfynol 420（占重量的 50%-10%）

2. SF-1328（占重量的 70%-95%），和 Surfynol 440（占重量的 30%-5%）

3. SF-1328（占重量的 60%-95%），和 SF-1488（占重量的 40%-5%）

4. SF-1528（占重量的 60%-95%），和 Surfynol 420（占重量的 40%-5%）

5. SF-1528（占重量的 70%-95%），和 Surfynol 440（占重量的 30%-5%）

6. SF-1528（占重量的 60%-95%），和 SF-1488（占重量的 40%-5%）

7. SF-1528（占重量的 50%-85%），Surfynol 440（占重量的 49%-5%）和 SF-1288（占重量的 1%-10%）

8. SF-1528（占重量的 50%-70%），Surfynol 440（占重量的 49%-5%）和 SF-1488（占重量的 1%-25%）

应当注意到，上述配方和材料，仅仅是为获得理想效果所使用的清洁剂的实施例。可使用任何有机的和/或有机硅氧烷基清洁剂，如前述众多的有机的和/或无机的有机硅氧烷复合物，并可同其他相关的清洁剂共同使用，只要其与易挥发硅氧烷干洗溶剂相匹配，可从纤维中去除水溶性灰土，并能防止其在干洗过程中再沉淀。

以下步骤特别地针对干洗方法实施例作了描述。

在步骤 1 中，服装或要干洗的其他物品，被放入一个垂直的洗涤、干燥一体机中，带有一个水平搅动洗衣筐（本领域技术人员熟知）。筐筒有许多孔洞，优选的是每孔直径 1/8-1/2 英寸。采用此尺寸的原因，是为了利用环状硅氧烷的低表面张力特性，利用离心力作用直接甩干。

在步骤 2 中，洗涤循环被引入由环状硅氧烷四聚物和五聚物组成的溶剂。优选的组合是占重量 80%四聚物和 20%五聚物。另外，环状硅氧烷溶剂可包括前述任何组合物。用来对前述混合物做调整

的添加剂，可在洗涤循环前加入，不必作为溶剂的组成部分。所述的添加剂，也就是清洁剂和悬浮制剂，允许溶剂完成服装的整个洗涤过程。将溶剂和清洁剂（如果使用了）从储存罐中泵入洗涤筐。洗涤物被搅动，对衣物进行机械揉搓，渗入的溶剂去除织物纤维中的尘垢和身体脂肪，所述的搅动持续 1-15 分钟。在洗涤循环中，溶剂和清洁剂（如果使用了）通过一个阀门泵出洗涤筐，然后流过一个过滤器。过滤器系统帮助去除混合物中的微粒和污物。在选择“批量”时，溶剂流会再使用，混合物不会进入过滤器系统，而从阀门直接泵回洗衣筐。可选择的形式有：任何类型的筒、圆盘、软管、硬管，单独使用或结合使用。另有一种选择，过滤结构由活性炭或硅藻土附加构成。

在步骤 3 中，衣物等被洗净，混合物从洗涤筐中被泵入工作罐，或蒸馏器，衣物等在离心力作用下除去尽可能多的混合物，剩余混合物被泵入，或自重进入目的装置。离心力过程根据具体情况持续 1-7 分钟，转速大于 350 转/分钟（RPM）；最好是 450 转/分钟-750 转/分钟。此过程使洗涤物中残存溶剂不超过 2-5%，通常为 3%。转速越高，离心力作用于旋转筐，去除溶剂速度越快。所述溶剂的低表面张力，最大程度地提高了离心过程去除溶剂的效力。

在步骤 4 和 5 中，服装在盛衣筐中翻滚，加热至 110-170 华氏度。所测温度是洗涤筐中所存含蒸汽的空气预缩合点温度。通过蛇形管注入加压蒸汽，使用一个循环通风器，加热盛衣筐中的空气，完成加热过程。与此同时，可在机器内产生部分真空，提供 50-600 毫米汞柱（大气压为 760 毫米汞柱）的负压，因而降低所述组分的汽化点，缩短时间。在此加热循环中，溶剂混合物被汽化，被循环空气带入冷凝蛇形管中，主气流中蒸汽被冷凝成液态，进行收集。气流可在闭环系统中被再次加热。一般是用 10-55 分钟，溶剂混合物从洗涤物中去除，被回收利用。

在步骤 6 中，加热循环停止，冷却循环开始。冷却循环可能会用 1-10 分钟。温度会从 110-170 华氏度降至 100 华氏度，优选的范围是 70-100 华氏度。此过程是通过排热，将空气在冷却管中循环，直至完成冷却过程。空气就是简单地利用加热管进行循环，只是加热管中不通蒸汽了。降温后取出衣物，可以减少起皱。温度较高时取出，则会引起褶皱。

在步骤 7 中，已用脏的硅氧烷，用液体环泵法（liquid ring pump）或有附加风扇的文氏管法，真空蒸馏，被再处理和净化。此过程是这样完成的：带有脏物的溶剂被泵入真空蒸馏器，真空蒸馏器展开槽排液的过程是帮助干燥的过程。热能是通过蒸汽加热管与展开槽接触提供的，温度范围是 230-300 华氏度。

环状硅氧烷沸点超过 150 华氏度。例如，四聚物沸点超过 175 华氏度，五聚物沸点超过 209 华氏度。不用真空，在正常沸点蒸馏所述的硅氧烷，会造成化学物质分解，也就是说，在 150 华氏度以上，环状结构会裂解为直链结构，导致形成甲醛。在本发明的一个实施例中，所提供的净化回收用过的环状硅氧烷装置，极具经济效益，可以保持环状结构完整，回收再生溶剂。真空蒸馏用过的环状硅氧烷溶剂，去除低沸点杂质，包括残存的水，以及高沸点杂质。

已发现环状硅氧烷，也就是四聚物和五聚物，在低温下，如 209 华氏度，生成共沸点混合物，导致纯水、纯溶剂及溶剂中可溶性杂质共同构成残留物。

以上描述了多种实施例，应当声明，本发明不限于此。因此，优选实施例的范围不应当受以上示范例的限制，应由以下权利要求及等效文件限定

说 明 书 附 图

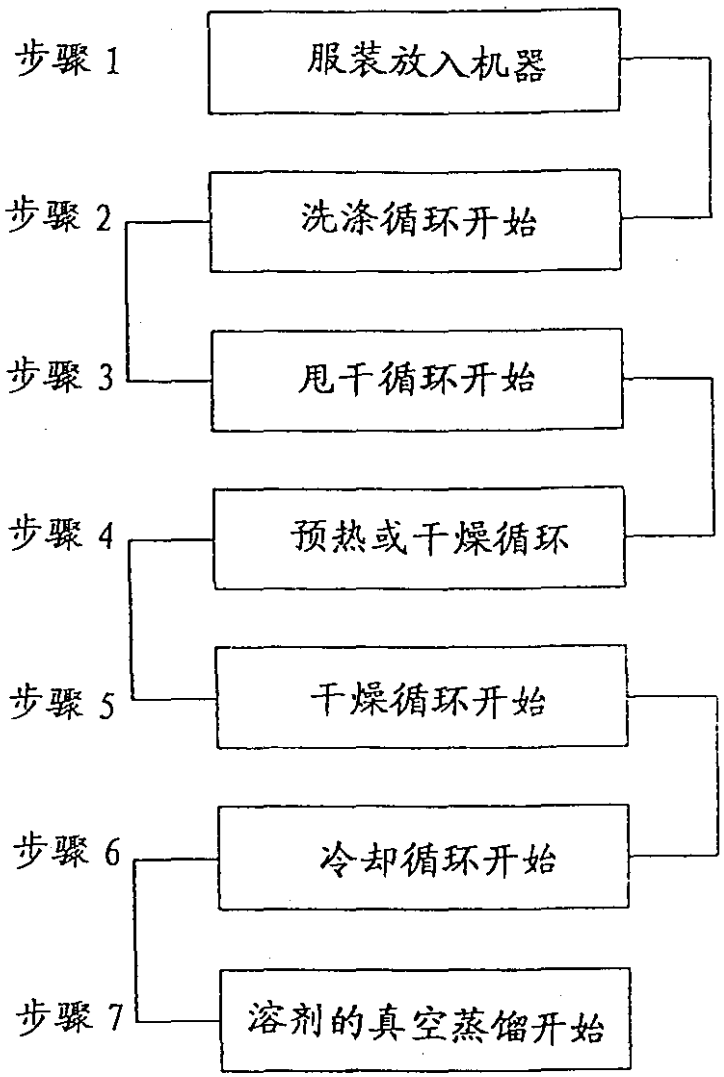
步骤 1
服装放入机器
步骤 2
洗涤循环开始
步骤 3
甩干循环开始
步骤 4
预热或干燥循环
步骤 5
干燥循环开始
步骤 6
冷却循环开始
步骤 7
溶剂的真空蒸馏开始

图 1