United States Patent Office 3,402,988
Patented Sept. 24, 1968

3,402,988

CHEMICAL DEACTIVATION OF CATALYST AT BOTH FACES OF A CELLULOSIC FABRIC IMPREGNATED WITH A RESIN-CATALYST SYSTEM TO IMPROVE ABRASION RESISTANCE OF FABRIC AFTER CURING

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No Drawing. Filed Apr. 2, 1965, Ser. No. 445,281
3 Claims. (Cl. 8—116)

ABSTRACT OF THE DISCLOSURE

This invention relates to a method for producing wrinkle and abrasion-resistant cellulosic textiles. More particularly, this invention relates to a method for producing wrinkle and abrasion-resistant cellulosic textiles that are essentially free of cross-linked cellulose molecules in selected portions of the textile but contain crosslinked cellulose molecules throughout the interior of the textile structure.

A non-exclusive, irrevocable, royalty-free license in the invention herein described, throughout the world for all purposes of the United States Government, with the power to grant sublicenses for such purposes, is hereby granted to the Government of the United States of America.

This invention relates to a method for producing wrinkle- and abrasion-resistant cellulosic fabrics and to the product so produced. More specifically, it deals with a method for producing wrinkle- and abrasion-resistant cellulosic textile fabrics that are essentially free of crosslinked cellulose molecules in selected portions of the fabric but contain crosslinked cellulose molecules throughout the interior of the fabric structure. The fabrics resulting from the process of this invention are characterized by excellent abrasion resistance, crease retention, unimpaired surface dyeing properties, smooth drying, and a high degree of wrinkle resistance.

The term "crosslinked cellulose" as used herein refers to cellulose molecules contained in cellulosic fibers that have been reacted with "a cellulose reactive reagent" (usually a polyfunctional reagent) to the end that adjacent cellulose molecules are joined together. Crosslinked cellulose is characterized by relative insolubility in conventional cellulose solvents, such as cuprammonium hydroxide.

The term "wash-wear finish" as used herein refers to a chemical treatment applied to cellulosic textiles for the purpose of crosslinking cellulosic molecules and imparting thereby wrinkle-resistance and smooth-drying properties to the textiles.

The present invention is related to copending application of Albert S. Cooper, Jr., and Wilson A. Reeves entitled "Abrasion Resistant Wash-Wear Cellulosic Fabrics," having Ser. No. 445,282 and filed concurrently herewith.

Heretofore cellulosic textiles treated with a wash-wear finish exhibited greatly reduced abrasion resistance and impaired receptability to dyes. The wash-wear finish in the conventional processes for producing wrinkle resistant fabrics penetrates the entire fabric structure causing crosslinking of the cellulose molecules throughout the fibrous structure. When these conventionally processed wash-wear fabrics are made into garments, such as shirts, dresses, and trousers, the fabrics soon show excessive abrasion at the pockets, collars, knees, creases, and at other exposed areas. The reduced abrasion resistance as compared to noncrosslinked cotton fabrics is due largely to crosslinked cellulose in the fibers located at the fabric surface. More

recently, wash-wear fabrics have been made into garments, especially men's trousers, through the use of delay-cured processes, and these garments exhibit sharp durable creases as well as wrinkle resistance and smooth drying properties. Trousers of this type fabricated predominately from cellulosic fiber exhibit very poor resistance to abrasion. Small holes, in some instances, are abraded in the cuffs and creases by merely laundering and tumble drying the garment a few times. Low abrasion resistance has caused many textile finishers to use fabrics containing a blend of noncellulosic and cellulosic fibers in an effort to overcome the loss in abrasion resistance. The use of these blends has caused a substantial increase in the cost of wash-wear fabrics and garments.

We have now discovered that wrinkle-resistant, smooth-drying cotton fabrics with durable creases, good shape-holding properties, excellent abrasion resistance, and unimpaired dyeing properties can be produced in a remarkably simple and efficient manner. The process of our discovery consists essentially of impregnating cellulosic fabric, using any of several conventional techniques, such as fogging, and immersion methods, with a wash-wear formulation containing a crosslinking agent, a catalyst for activating the crosslinking agent, and auxiliary finishing agents; subsequently, applying a catalyst deactivator to the top, the bottom, or both, of the fabric, care being exercised to prevent the deactivator from penetrating the entire thickness of the fabric. The catalyst is thereby neutralized or deactivated only in those regions of the fabric penetrated by the deactivator. The fabric is then dried, and finally heated for at least 1.5 minutes at an elevated temperature.

The process of our invention is compatible with both conventional fabric finishing equipment and conventional fabric finishing processes, and we have accordingly operated the process on commercial-size equipment.

The improved abrasion resistance and other properties, which characterize the fabrics finished according to the process of our invention, as compared with the corresponding properties of wash-wear fabrics produced by the prior art processes, is due to the absence of crosslinked cellulose at or near the surface of the fabric.

Crosslinking agents suitable for use in this invention include reagents that contain two or more functional groups that are capable of reacting with cellulose when activated by a catalyst. In general, the crosslinking agents are those used in conventional processing methods by the textile finishing industry for the production of wash-wear cellulosic fabrics and are also well known as crease proofing agents for cellulose. Typical examples are dimethylol urea, dimethylol ethylene urea, N,N'-dimethylol-4,5-dihydroxy ethylene urea, dimethylol hydroxy ethyl carbamate, bis-methoxymethyl-ethyl carbamate, tris-(1-aziridinyl)phosphine oxide, vinyl cyclohexene diepoxide, formaldehyde, methylol and methylolated methylol triazine derivatives, acetals, and the like.

The nature of the crosslinking agent is in no way a limiting feature of this invention except that its reaction with cellulose must be activated by a suitable catalyst.

The amount of crosslinking agent employed will depend to some extent upon the commercial equipment employed and the type of fabric used. Aqueous solutions of the crosslinking agent ranging from about 4 to 20 weight percent (on the weight of the solution) (OWS) when the wet pickup is about 60 to 70 weight percent on the weight of the cellulosic material (OWF) cause good results to be obtained. The dry weight of the crosslinking agent will range from about 2 to 15 weight percent (OWF).

Catalysts suitable for use in this invention are those commonly used with crosslinking agents of the type listed above. Typical examples are amine hydrochlorides, mag-

nesium chloride, zinc nitrate, and zinc fluoroborate. The nature of the catalyst is likewise not a limiting feature of this invention.

The amount of catalyst employed will depend upon the amount of crosslinking agent. However, amounts ranging from about 1 to 5 weight percent (OWS) is a good practice. The particular catalyst to be used with a particular crosslinking agent is known to those skilled in the art.

Auxiliary agents suitable for use in this invention are softeners, wetting agents, optical whiteners, and other commonly used finish modifiers. These auxiliary agents are not limiting features of this invention.

The prescribed use of a catalyst deactivator is the critical feature of this invention. The term catalyst deactivator as used herein refers to a Lewis base capable of reacting with the catalyst which induces the crosslinking reaction to neutralize or otherwise make it ineffective for promoting the crosslinking of cellulose. Typical deactivators include sodium and other alkali hydroxides, $NaHCO_3$, Na_2CO_3, $Ca(OH)_2$, NH_3, amine salts, aliphatic and aromatic amines, salts of carboxylic acids, such as sodium carboxymethyl cellulose, and zirconyl ammonium carbonate. The controlled penetration of the deactivator into the fabric is of utmost importance. The deactivator may be applied to the fabric surface by coating procedures, by spraying, fogging, or by exposure of the fabric to basic vapors. Regardless of the method of applying the deactivator, a critical feature of this invention is that the deactivator contact the surface and penetrate less than about one-half the thickness of the fabric whether applied to one or both sides of the fabric.

When the deactivator is applied to the fabric by use of coating devices, the viscosity of the deactivator or its carrier should be great enough to limit its penetration into the fabric less than about one-half the thickness of the fabric. Penetration will be discussed below. The type of coating device is not critical as long as it is capable of applying an adequate amount of the deactivator. Many compounds and polymers are suitable for regulating the viscosity. Typical substances include starch, derivatized starch, hydroxyethyl cellulose, methyl cellulose, carboxymethyl cellulose, silica, gelatin, polyoxyethylene, and agar-agar. The preferred viscosity regulating compounds are those that impart adequate increase in viscosity with less than about 10% of the substance in suspension or solution. The viscosity regulating agent may contain groups such as the hydroxy that are capable of reacting with the crosslinking agent but this is not a requirement. The viscosity regulating agents which do contain such groups become chemically bound to the fabric and increase the stiffness of the treated fabric which is desirable for many end uses of the fabric. The catalyst-deactivator liquid may also contain a water insoluble film-forming polymer, such as nylon, polyurethane, silicones, fluorocarbons, and polyethylene which may be deposited on the surface of the fabric and become firmly fixed to the fibers through mechanical or secondary valence forces when the fabric is subsequently dried and heated above 100° C. The primary purpose of these polymers is to provide a highly abrasive-resistant polymer on the fibers at the surface of the fabric. The catalyst deactivator can be applied to the wet fabric immediately after the wash-wear formulation is applied; or the fabric can be dried first. When the latter method is used, the fabric is again dried after the catalyst-deactivator is applied.

Penetration of the deactivator into a fabric structure is controlled by (1) regulation of viscosity of the fluid system, (2) controlling the time lapse between application of the deactivator and immobilization of it by drying the wet fabric, and (3) regulating the concentration of the deactivator in the fluid system. Fabric weight and surface structure determine the limitations of these variables. The sooner the fabric is dried after the deactivator is applied the more limited will be the extent to which the deactivator penetrates the fabric, assuming viscosity and concentration are held constant. Preferably, the fabric is dried within about five minutes after the deactivator is applied to the fabric.

After the deactivator is applied, the fabric can be dried and cured to promote the crosslinking reaction in a single operation or the fabric can be dried, made into garments, and finally cured in garment form. When the fabric is to be dried and cured in a single operation, the temperature should be above about 285° F. and the heating should be applied for at least about 1.5 minutes. When the fabric is to be dried, later made into garments and subsequently cured, the fabric should be dried to a moisture content of less than about 15% by heating at a temperature of less than about 260° F. The dried, but uncured, fabric can be made into a garment such as trousers or blouses and creases and pleats can be set in the fabric at desired locations by pressing with a hot iron. The final cure or heat treatment cure which promotes reaction of the crosslinking agent with the cellulose molecules can then be done with a hot iron, hot head press, but is done preferably in a forced draft hot air oven. The cure temperature in any case should be above about 285° F., and the time ranges from about 1.5–15 minutes, depending upon the weight of the fabric to be cured and the amount of crosslinking agent contained in the fabric.

Fabrics suitable for use in this invention are composed largely of cellulosic fibers. The fibers may be of natural or synthetic origin. They may be grey, scoured, mercerized, bleached, or dyed goods. Cotton and rayon fibers are particularly suitable. When the fabric is composed of blends of noncellulosic and cellulosic fibers, the cellulosic fibers should make up at least 50% of the fabric weight. The fabrics may be of the conventional nonstretch type or they may have a high degree of stretch and recovery. The stretch may be provided by crimped yarn such as that produced by crimped nylon yarn or the stretch fabric may be slack mercerized cotton or rayon fabric. It is essential that the cellulosic fibers in such stretch fabrics be free from previous wash-wear finishes. The use of stretch fabrics is particularly desirable when a very high degree of abrasion resistance is desired.

It is within the scope of our invention to apply the crosslinking agent to a dyed, or undyed, fabric and subsequently deactivate the catalyst in selected portions of the cellulosic material. This may be on one side, on both sides, or by printing designs on one or both sides. When the treated fabric is dried and heat-treated, the portions that have been treated with the catalyst deactivator remain unmodified and may be dyed with cotton dyes to give a solid shade or a design on the dyed, or undyed, background. Typical cotton dyes suitable for dyeing are the commercially available vat dyes, such as Vat Yellow 1 (Color Index No. 70600), Vat Orange 1 (Color Index No. 59105), Vat Orange 4 (Color Index No. 59710), Vat Red 1 (Color Index No. 73360), Vat Violet 1 (Color Index No. 60010), Vat Brown 1 (Color Index No. 70800), Vat Green 1 (Color Index No. 59805), or combinations thereof. Vat dyes are preferred for cellulosic materials that will be subjected to hard wear, and considerable washing.

Other dyes that may be employed are the direct cotton colors, such as Direct Yellow 4 (Color Index No. 24890), Direct Yellow 6 (Color Index No. 40001), Direct Orange 1 (Color Index No. 22375), Direct Violet 9 (Color Index No. 27885), Direct Blue 67 (Color Index No. 27925), or combinations thereof, and the like. While we have given the above dyes by way of illustration, we are not limiting our invention to these particular dyes. The color index numbers of the dyes, shown in parentheses, were taken from Color Index, 2nd Edition, 1956.

It is an advantage of this invention that when a dyed fabric has been impregnated with the crosslinking agent, a catalyst deactivator applied, and the treated cellulosic material subsequently cured, subsequent dyeing with a dye

having a different shade enables the opeartor to determine the depth to which the deactivating chemical is pentrating into the fabric as the crosslinked or modified cellulosic material will be dyed a different shade than the unmodified surface.

It is a further advantage of our invention that the shade and depth of color of the dyed, wash-wear, abrasion-resistant fabrics of this invention are not impaired by the presence of a nitrogenous crosslinking agent. It is well known that many wash-wear finishes based upon nitrogenous crosslinking agents cause accelerated fading of dyes when exposed to ultraviolet or visible light waves. Just why this occurs is not presently understood. However, the shades of the dyed products of our invention do not exhibit accelerated fading because the surface of the dyed fabric is free from crosslinked cellulose.

Some finishes on white goods based upon crosslinking agents applied by conventional processes become yellow or discolored when heated, as by ironing, or drying in a home dryer, or when bleached with hypochlorite. This discoloration limits the usefulness of such crosslinking agents to materials dyed a dark shade. It is a further advantage of our invention that such finishes can be used in the production of undyed products without exhibiting this discoloration because the surface of the fabric is free of the finish that produces the discoloration.

It is a still further advantage of the product of our invention that the original tensile strength of the preferentially-crosslinked fabric is higher than when the crosslinking material is distributed throughout the fabric. Most important, the wrinkle resistance of the fabric is just as good as though the crosslinking material was distributed throughout the fabric structure. This was unexpected.

In another embodiment of this invention, polyfunctional reagents capable of crosslinking cellulosic molecules and which are catalyzed by Lewis bases may be used. After impregnating the cellulosic materials with an aqueous solution comprising the polyfunctional agent and a polymerization catalyst for said polyfunctional reagent, these catalysts may then be deactivated by Lewis acids in selected portions of the fabric. These selected portions may be on one or both sides (surfaces) of the fabric or as designs. However, it is a critical feature of this embodiment that the catalyst-deactivator penetrates less than half the thickness of the cellulosic material so that the molcules of cellulose in the interior are crosslinked after a heat-cure.

Polyfunctional reagents which may be used include dimethylol urea, bis(hydroxyethyl) sulfone, vinyl cyclohexane diepoxide, epichlorhydrin, tris-(sulfatoethyl), and sulfonium chloride, and the like.

Lewis bases which may be used to catalyze these polyfunctional agents are alkali carbonate, alkalies, and alkali bicarbonates.

Lewis acids suitable for deactivating the Lewis-base catalysts include solutions of acetic acid, hydrochloric acid, oxalic acid, zinc nitrate, magnesium chloride, and the like. The deactivator may be applied by any of the methods described above.

The following examples are set forth by way of illustartion only, and it will be understood that the invention is not to be construed as limited in spirit or in scope by the details therein. Temperatures are given in degrees Fahrenheit unless otherwise noted. All parts and percentages are by weight. When the weight is based on the solution it will be noted (OWS).)When the weight is based on the weight of the fiber it will be noted (OWF). Fabrics dyed with "vat" dyes are applied by conventional vat-dyeing procedures. Dyeings with "direct" dyes are also applied by conventional direct-dyeing procedures. Test results are according to standard test methods, as designated by the American Association of Textile Chemists and Colorists (AATCC) or the American Society for Testing Materials (ASTM).

Example 1

A sample of 48", 1.21 yd., 76 x 132, midwale corduroy is desized, scoured, and dyed with a brown vat dye using standard vat-dyeing procedures. The fabric is then dried at a width of 45". The dry, desized, scoured, and dyed fabric is then passed into and through a solution containing 12% of the dimethylol derivative of N,N'-dimethylol-4,5-dihydroxy ethylene urea, 2.2% magnesium chloride hexahydrate, 2% polyethylene softener, balance water. The thoroughly impregnated fabric is squeezed to a wet takeup of 65 weight percent. The fabric is then dried at 250° F. for about one minute to obtain a moisture content of about 10% by weight of the fabric. The dry fabric is then knife-blade coated with a solution of 0.8% hydroxyethyl cellulose and 0.8% sodium bicarbonate. The solution has a viscosity of about 25 poises at 25° C. and the coating speed and knife-blade pressure are set to obtain a wet takeup of about 40% based on the weight of the fabric. This coating treatment provides sufficient sodium bicarbonate to neutralize approximately ⅓ of the magnesium chloride hexahydrate catalyst present in the fabric. The fabric is then dried for about one minute at 250° F. After drying, the fabric is hot pressed to form pleats and creases. The fabric is then heat-cured at 320° F. for about 10 minutes. After curing, the fabric is washed in water containing about 0.1% scouring assistant, then dried, and tested.

The results follow:

(1) The surface of the fabric coated with the catalyst-inactivating agent when dyed with Direct Blue 67 is similar in shade to untreated cotton when dyed with the same dye.

(2) The surface and interior portion of the fabric not treated with the catalyst-inactivating agent resisted dyeing with the Direct Blue 67.

(3) The portions of fibers shaved from the surface of the fabric that received a catalyst-inactivation treatment are soluble in cuprammonium hydroxide and cupriethylene diamine hydroxide (cuene) as are untreated cotton fibers. This test indicates that crosslinking has not occurred between the cotton cellulose molecules of the surface fibers.

(4) The portion of fibers shaved from the surface of the fabric (dyed brown) which did not receive a catalyst-inactivation treatment are insoluble in all normal cellulose dissolving agents, such as cupriethylene diamine hydroxide (cuene). This test indicates that the cotton cellulose molecules are covalently crosslinked. For those fibers that pass from one surface to the other, in each case the portion of the fiber is soluble or insoluble depending on whether it has been reached by the catalyst-inactivation treatment or has not.

(5) The wrinkle-resistance and smooth-drying properties of the treated fabric are much improved in comparison to the untreated cotton fabric. According to AATCC test method 88C–1964T, the treated fabrics had a wash-wear rating of 5 after home laundering and tumble drying. The untreated fabrics had a rating of 2 after the same treatment.

(6) The results of flex and flat abrasion test according to ASTM–D1175–61T, Method B, show that the side of the fabric given the catalyst-inactivation treatment has abrasion proporties similar to untreated cotton and has as much as 10–20 times more resistance to abrasive damage than fabric not given the catalyst-inactivation treatment, or a fabric that has been given a conventional pad-dry-cure resin treatment.

(7) Creases and pleats pressed into the fabric prior to curing are very sharp and durable through repeated wash- and tumble-dry cycles. There is no evidence of edge abrasion or fibrilation as is typically experienced with the surface of wash-wear fabrics produced by conventional wash-wear processes.

When quantities of other Lewis bases, such as alkali-metal hydroxides, calcium hydroxide, triethanolamine,

and the sodium salt of carboxymethyl cellulose equivalent to 0.8 weight percent (OWS) of sodium bicarbonate are used, generally similar results are obtained.

Example 2

A sample of 46", 1.95 yd., 128 x 56, twill is desized, scoured, and dyed an olive drab shade using the required combination of vat dyes. The fabric is then dried at a width of 43". The dry, desized, scoured, and dyed fabric is padded into, and through, a solution containing 12% dimethylol ethylene urea, 2% magnesium chloride hexahydrate, 2% polyethylene softener, and the balance water to thoroughly impregnate the cellulosic material. The thoroughly impregnated fabric is squeezed to a wet pick-up of about 65%. The fabric is then dried at 250° F. for about 45 seconds to obtain a moisture content of about 10% by weight of the fabric. The dry fabric is then knife-blade coated successively on the face and on the back with a solution of 1.0% hydroxyethyl cellulose and 0.8% sodium bicarbonate. This solution has a viscosity of about 45 poises at 25° C., and the coating speed and knife-blade pressure were set to obtain a combined (i.e., top and bottom side) wet takeup of about 40% based on the weight of the fabric, or a takeup of approximately 20% on each side. This coating treatment provides sufficient sodium bicarbonate to neutralize approximately ½ of the magnesium chloride hexahydrate catalyst in the fabric. This is equivalent to neutralizing approximately ⅛ of the fabric on each side. The fabric is then dried for about 45 seconds at 250° F. After drying the fabric is pleated and creased by hot pressing. It is then cured at 320° F. for about ten minutes. After curing the fabric is washed in an aqueous bath containing 0.1% scouring assistant, dried, and tested.

The results follow:

(1) The surfaces of the fabric coated with the catalyst-inactivating agent when dyed with Direct Blue 67 is similar in shade to untreated cotton when dyed with the same dye.

(2) The interior portions of the fabric not treated with the catalyst-inactivating agent resisted dyeing with the Direct Blue 67.

(3) The portions of fibers shaved from either fabric surface that received a catalyst-inactivation treatment are soluble in cuprammonium hydroxide and cupriethylene diamine hydroxide (cuene) as are untreated cotton fibers. This test indicates that crosslinking has not occurred between the cotton cellulose molecules of the surface fibers.

(4) The portions of fibers removed from the interior of the fabric (dyed olive drab) which did not receive a catalyst-inactivation treatment are insoluble in all normal cellulose dissolving agents, such as cupriethylene diamine hydroxide (cuene). This test indicates that the cotton cellulose molecules are covalently crosslinked. For those fibers that pass from one surface to the other, in each case the portion of the fiber is soluble or insoluble depending on whether it has been reached by the catalyst-inactivation treatment or has not.

(5) The wrinkle-resistance and smooth-drying properties of the treated fabric are much improved in comparison to the untreated cotton fabric. According to AATCC test method 88C–1964T, the treated fabrics had a wash-wear rating of 5 after home laundering and tumble drying. The untreated fabrics had a rating of 2 after the same treatment.

(6) The results of flex and flat abrasion test according to ASTM–D1175–61T, Method B, show that the side of the fabric given the catalyst-inactivation treatment has abrasion properties similar to untreated cotton and has as much as 10–20 times more resistance to abrasive damage than fabric not given the catalyst-inactivation treatment, or a fabric that has been given a conventional pad-dry-cure resin treatment.

(7) Creases and pleats pressed into the fabric prior to curing are very sharp and durable through repeated wash- and tumble-dry cycles. There is no evidence of edge abrasion or fibrilation as is typically experienced with the surface of wash-wear fabrics produced by conventional wash-wear processes.

When quantities of other Lewis bases, such as alkali-metal hydroxides, calcium hydroxide, triethanolamine, and the sodium salt of carboxymethyl cellulose equivalent to 0.8 weight percent (OWS) of sodium bicarbonate are used, generally similar results are obtained.

Example 3

A sample of 40", 4 yd., 80 x 80, printcloth is desized, scoured, and dyed with a brown vat dye. The fabric is then dried at a width of 37". The dry desized, scoured, and dyed fabric is passe into, and through, a solution containing 10% dimethylol ethyl carbamate, 2% magnesium chloride hexahydrate, 2% polyethylene softener, balance water. The thoroughly impregnated fabric is squeezed to a wet takeup of about 70%. The fabric is dried for 18 seconds at 250° F. to obtain a moisture content of about 10% or about normal regain moisture content. The dry fabric is then passed through a fogging chamber containing 0.4 weight percent sodium hydroxide in water solution and in a very finely divided spray. The rate of passage of the fabric through the fogging chamber, dwell time, is set to obtain a wet takeup of about 40%. The sodium hydroxide concentration is adjusted to neutralize from approximately one-fourth to one-half of the catalyst in the fabric. The fabric is then dried for 25 seconds at 250° F. Pleats and creases are hot pressed into the fabric. The fabric is then cured at 320° F. for eight minutes. After curing, the fabric is washed in an aqueous solution containing 0.1% scouring assistant, dried, and tested.

The results follow:

(1) The surfaces of the fabric treated with the catalyst-inactivating agent when dyed with Direct Blue 67 is similar in shade to untreated cotton when dyed with the same dye.

(2) The interior portions of the fabric not treated with the catalyst-inactivating agent resisted dyeing with the Direct Blue 67.

(3) The portions of fibers shaved from either fabric surface that received a catalyst-inactivation treatment are soluble in cuprammonium hydroxide and cupriethylene diamine hydroxide (cuene) as are untreated cotton fibers. This test indicates that crosslinking has not occurred between the cotton cellulose molecules of the surface fibers.

(4) The portions of fibers removed from the interior of the fabric (dyed brown) which did not receive a catalyst-inactivation treatment are insoluble in all normal cellulose dissolving agents, such as cupriethylene diamine hydroxide (cuene). This test indicates that the cotton cellulose molecules are covalently crosslinked. For those fibers that pass from one surface to the other, in each case the portion of the fiber is soluble or insoluble depending on whether it has been reached by the catalyst-inactivation treatment or has not.

(5) The wrinkle-resistance and smooth-drying properties of the treated fabric are much improved in comparison to the untreated cotton fabric. According to AATCC test method 88C–1964T, the treated fabrics had a wash-wear rating of 5 after home laundering and tumble drying. The untreated fabrics had a rating of 2 after the same treatment.

(6) The results of flex and flat abrasion tests according to ASTM–D1175–61T, Method B, show that the side of the fabric given the catalyst-inactivation treatment has abrasion properties similar to untreated cotton and has as much as 10–20 times more resistance to abrasive damage than fabric not given the catalyst-inactivation treatment, or a fabric that has been given a conventional pad-dry-cure resin treatment.

(7) Creases and pleats pressed into the fabric prior to curing are very sharp and durable through repeated wash- and tumble-dry cycles. There is no evidence of edge abra-

sion or fibrilation as is typically experienced with the surface of wash-wear fabrics produced by conventional wash-wear processes.

When quantities of other Lewis bases, such as alkali-metal hydroxides, calcium hydroxide, triethanolamine, and the sodium salt of carboxymethyl cellulose equivalent to 0.8 weight percent (OWS) of sodium bicarbonate are used, generally similar results are obtained.

We claim:

1. A process for producing a wrinkle-resistant, smooth-drying, and high abrasion-resistant woven cellulose fabric, comprising

(a) impregnating a woven cellulose fabric containing cellulose yarns entirely through its cross section with a solution containing a crosslinking, creaseproofing agent for cellulose and a catalyst for activating said crosslinking, creaseproofing agent;

(b) drying the thus-impregnated fabric;

(c) applying a catalyst-deactivator to the dried, impregnated fabric so that it contacts both entire surfaces of the fabric and that portion of the interior of the fabric cross section which is continuous with each of the surfaces and which extends to less than about ½ of the thickness of the fabric, to deactivate said catalyst in the areas contacted; and

(d) heating the resulting fabric at an elevated temperature to effect reaction between the crosslinking, creaseproofing agent and that portion of the interior of the fabric in which the catalyst has not been deactivated.

2. The process of claim 1 wherein the impregnating solution contains about from 4 to 20 weight percent of the crosslinking, creaseproofing agent and about from 1 to 5 weight percent of the catalyst, said percentages being based on the weight of the solution, and the wet pickup is about from 60 to 70 weight percent based on the weight of the fabric.

3. The process of claim 1 wherein the catalyst-deactivator is a base of the Lewis type.

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