United States Patent Office 3,483,570
Patented Dec. 16, 1969

3,483,570

ABRASION RESISTANT WASH-WEAR CELLULOSIC PRODUCTS

Charles H. Fisher, Nestor B. Knoepfler, Emery C. Kingsbery, and Robert J. Cheatham, New Orleans, and Henry L. E. Vix, Metairie, La., assignors to the United States of America as represented by the Secretary of Agriculture

No Drawing. Filed July 9, 1965, Ser. No. 470,939
Int. Cl. D02g 3/36, 3/04
U.S. Cl. 2—243 12 Claims

ABSTRACT OF THE DISCLOSURE

Cellulosic fibers are impregnated with an aqueous solution of a catalyst and a thermosetting resin which may include a thermoplastic resin and dried at a temperature low enough to inhibit resin curing. Such fibers are then blended with untreated cellulosic fibers and, subsequent to forming (1) a yarn from said blend, (2) a fabric from said yarn or (3) a garment from said fabric, heated at elevated temperatures to promote resin curing.

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 resilient textile products and to the products so produced. More specifically, the invention deals with a method for producing resilient, wash-wear type cellulosic textile products from yarns composed of blends of partially-modified cellulosic fibers and untreated fibers and having excellent fiber-and-yarn mobility. Still more specifically, the invention deals with a novel process for the preparation of these partially-modified cellulosic yarns having fiber mobility from cotton (staple) fibers. When these partially-modified cellulosic yarns are converted into fabrics or other products and subsequently exposed to a high-temperature "cure," the resultant resilient products are characterized by excellent abrasion resistance, while retaining unimpaired crease-retention, wrinkle-resistance, and smooth-drying properties.

As used herein, the term "textile products" includes fabrics and articles manufactured from fabrics such as blouses, dresses, shorts, shirts, trousers, curtains, draperies, and the like.

The term "partially-modified cellulosic yarns" relates to a cellulosic yarn spun from blends of fibers and/or filaments, a portion of which blend has been "partially treated" in the fiber form with a delayed-cure, crosslinking agent and the remaining portion is untreated. The resultant spun yarn comprises from about 10 to 90 weight percent of the partially-treated product on the total weight of the yarn. By "partial treatment" is meant that the cotton fibers or other cellulosic fibers have been treated with an aqueous solution of a crosslinking agent and a catalyst for the crosslinking agent in such a manner that the curing step which is carried out at high temperatures to complete crosslinking is delayed. The yarns may be either singles or plied.

It is a prime object of this invention to treat cellulosic fibers with delayed-cure, crosslinking agents and, without curing the crosslinking agent, to process blends of the

treated fibers with untreated cellulosic fibers into yarns which, after curing, retain excellent fiber mobility.

It is a further object to convert these yarns having excellent fiber mobility, into delayed-cure fabrics which, upon subsequent curing, have satisfactory wash-wear properties, fiber-and-yarn mobility and unexpectedly high resistance to abrasion.

It is a still further object to convert the delayed-cure fabrics having latent fiber-and-yarn mobility into garments or other cellulosic products prior to curing the crosslinking agent. The resultant cured products have excellent resiliency, crease-retention, shape-holding, and wash-wear properties. Most important, the retained fiber-and-yarn mobility of the cured fabrics, or garments, imparts high resistance to abrasion.

Heretofore, cellulosic textile fabrics have been treated to produce wash-wear finishes by immersing the entire fabric in an aqueous solution comprising a suitable crosslinking agent and a catalyst to activate the crosslinking agent, removing the excess aqueous solution by squeezing between padder rolls or by centrifuging, drying the wet fabric, and subsequently "curing" the dry fabric to complete the crosslinking reaction between the agent (usually a synthetic resin) and the cellulose molecule. During this treatment the wash-wear finish penetrates the entire fabric and also into the interior of the fibers or filaments of which the fabric is composed. As a result, the fabric impregnated with a wash-wear finish has greatly reduced abrasion resistance. Consequently, when these conventionally processed wash-wear fabrics are made into garments such as dresses, shirts, blouses, shorts, trousers, and the like, the fabrics soon show excessive abrasion at the collars, knees, creases, cuffs, and at other areas exposed to wear. The reduced abrasion resistance as compared with noncrosslinked cellulosic materials is due largely to crosslinked cellulose in the fibers located at the fabric surface, which eliminates the ability of the fibers and/or yarns to move. 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. However, trousers of this type fabricated predominantly from cellulosic fibers 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. This 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 after resin treatment. The use of these blends has caused a substantial increase in the cost of wash-wear fabrics.

We have now discovered that wrinkle-resistant, smooth-drying fabrics containing durable creases, good shape-holding properties, and excellent abrasion resistance can be produced in a remarkably simple and unexpected manner by treating staple cotton fibers (frequently referred to herein as "fibers") with a crosslinking agent, *but without curing the agent,* and thereafter blending the dry, treated fibers with *untreated* cotton fibers. The blend is then carded, drawn, and spun into yarn. The yarn may then be cured, or, without curing, it may be woven into fabrics, after which the uncured crosslinking agent (resin) is cured by heat treatment at elevated temperatures. Or, the uncured fabric may be converted into garments or other commercial products which may be creased in selected locations and hot pressed, after which the crosslink-

ing agent is cured by exposure to high temperatures for a suitable time. The resultant cured yarns, fabrics, or garments are composed of a *blend of modified (crosslinked) and unmodified fibers,* retain excellent fiber-and-yarn mobility, and a high degree of resistance to abrasive damage such as is encountered in home-type washing machines and tumble dryers.

In general, the process of our invention may be described as follows:

(a) Opened cotton fibers, preferentially cotton fibers that have been scoured and bleached, are fed (passed) by suitable means into a treating bath comprising an aqueous solution of a synthetic resin (crosslinking or treating agent) and a catalyst for said resin;

(b) A period of dwell (residence time) is then maintained to permit the aqueous solution to wet the fibers;

(c) The excess aqueous solution is then removed to give a wet pickup of about 85 to 110 weight percent on the weight of the fibers (OWF);

(d) The wet fibers are then dried at a temperature *not over* 200° F. to a moisture content of not less than 10 weight percent;

(e) The dried fibers are then permitted to equilibrate at ambient room temperature and humidity to reduce the moisture further to about 5.5 to 8.0 weight percent of the total weight of the fiber and the deposited resin (chemical). This may require from about 15 to 24 hours.

(f) The resin treated and equilibrated fibers are then blended with untreated cellulosic fibers;

(g) The blends are then converted into yarns of a predetermined size and twist by the conventional processing steps for converting cotton fibers into yarns;

(h) The yarns are then crosslinked, or cured, by heating them at a temperature from about 240° F. to 350° F. for about 20 to 3 minutes whereby resilient yarns having excellent fiber mobility and capable of producing resistance to abrasion are obtained.

(i) In another embodiment of this invention, the blended yarns of step (g), without curing, may be woven into a fabric after which the fabric may be exposed to elevated temperatures of about 240° to 350° F. for appropriate periods of time to "cure" or effect crosslinking. About 3 to 8 minutes at about 325° F. is a good practice.

(j) In still another embodiment of our invention, the uncured fabric is converted into garments, creased, pressed, or otherwise physically altered at selected locations by means of hot-pressing or other means known to those skilled in the art, after which the garment is cured by exposure to similar high temperatures for appropriate periods of time to effect crosslinking of the thermosetting or thermoplastic resins.

The process is simple and easily applied. The cellulose fibers may be treated by conventional means known to those skilled in the art. After treatment, the equilibrated uncured staple fibers are blended with unscoured; or scoured; or scoured and bleached cellulosic fibers in varying amounts and processed into yarns, fabrics, and other cellulosic products (such as garments, knit goods, curtains, draperies, etc.,) by conventional cotton processing equipment, or equipment required to fabricate the other products. Due to the presence of the potential (latent) properties of crosslinking ability with the cellulose molecule, and the application of these agents prior to any mechanical operations directed at making yarns or fabrics, these yarns, fabrics, and garments after curing retain a high degree of fiber-and-yarn mobility and also excellent properties of wrinkle-resistance, smooth-drying, durable-creasing, and good shape-holding. Most important, the resultant products are characterized by excellent resistance to abrasion.

Preparation of aqueous solutions of treating agents

Crosslinking agents suitable for use in the practice of our invention include reagents that contain two or more functional groups that are capable of reacting with the cellulose or with themselves. Two types of crosslinking agents have caused excellent results to be obtained, namely, essentially monomeric thermosetting crosslinking agents and essentially monomeric thermoplastic crosslinking agents. As will be more fully explained in the examples, either the warp yarns, the filling yarns, or both warp and filling yarns may be spun from blends of the treated and untreated fibers.

Typical examples of essentially monomeric, commercially available thermosetting crosslinking agents are N,N'-dimethylol-4,5-dihydroxy cyclic ethylenurea, dimethylol hydroxyethyl carbamate, bis-methoxymethyl ethylcarbamate, vinyl cyclohexene-diepoxide, acetals, and related crosslinking agents that have a slow rate of cure (long shelf life) under ambient conditions of temperature and humidity. Typical examples of essentially monomeric, thermoplastic crosslinking agents are the commercially available vinyl acrylic resins, self-crosslinking acrylic resins, vinylidine chloride modified acrylics, styrene-butadiene resins, vinyl acetates, butadiene-acrylonitrile-styrene terpolymers, styrene-methylolpolyamide copolymers, vinylmethylolpolyamide copolymers, acrylo-methylolpolyamide copolymers, and the like. Although these latter resins are designated as "copolymers" or "terpolymers," they are "essentially monomeric" and capable of crosslinking and form a thin tough film around the fiber.

The self-crosslinking acrylics do not crosslink to any appreciable extent until they are cured at a temperature over 240° F. Until this time, the resins exhibit thermoplastic behavior. After curing, the acrylic resin exhibits both thermosetting and thermoplastic properties. The better the cure, the greater the number of crosslinks and the more the properties of this type of resin resemble those of a thermosetting resin. The cure can be made on the yarn, or the fabric; or the fabric may be converted into garments and then cured. As noted above, these resins form a thin, tough film around the individual fibers.

Regardless of the type used, the concentration of the crosslinking agent in the treating bath should be adequate to deposit from about 1 to 20 weight percent *dry* resin add-on after the fibers have been dried and equilibrated. Usually, concentrations of about 1 to 20 weight percent on the weight of the solution (OWS) with a subsequent wet pickup of about 85 to 110 weight percent on the weight of the fiber (OWF) is a good practice.

Catalysts suitable in this invention are those commonly used with the crosslinking agents of the types listed above. For the thermosetting resins, typical examples include zinc nitrate, zinc fluoroborate, solutions of zinc salts buffered with organic acids such as acetic acid, magnesium chloride, and metallic salt complexes containing zinc. For the thermoplastic resins, typical examples include oxalic acid, magnesium chloride, 2-amino-2-methyl-1-proponal hydrochloride, zinc nitrate, and similar acid or latent acid catalysts. Latent acid catalysts refer to products which become effective at curing temperatures. However, in order to be suitable for the practice of the present invention, these catalysts must be neutralized, or buffered, where necessary, so that the aqueous crosslinking solution containing the catalysts is neutral or slightly acidic. In general, it is preferred that the pH of the aqueous crosslinking solution be in the pH of the aqueous crosslinking solution to be in the range of 3 to 7. Low pH's, i.e., about 2 or lower, are not suitable because of the increased susceptibility of the crosslinked, uncured fibers to "cure" during the subsequent conventional cotton processing or storage. Also, there is a potential danger of acid-tendering of the treated fibers. Alkaline pH's, i.e., above 7, are likewise unsuitable. Use of alkaline pad baths results in reduced efficiency of the crosslinking reaction, produces yellowing of the yarns and/or fabric upon heating, and reduce the quality of durability of wash-wear properties and creases imparted to the cellulosic product. A particularly suitable pH range for the aqueous crosslinking solution of the present invention is 5 to 7, preferably

5–6.5. The adjustment of the pH of the latent acid-forming catalysts, zinc nitrate, and magnesium chloride, to produce the aqueous crosslinking solution having a pH of 6.5 or slightly lower may be accomplished by the addition of any compatible alkaline agent or by the use of buffers. The zinc nitrate catalyst should not be buffered or neutralized to above a pH of 6.5 to avoid precipitation of water-insoluble, noncatalytic zinc hydroxide. Should this precipitate appear, addition of a few drops of acetic acid is usually sufficient to reduce the pH of the aqueous crosslinking solution to a pH below 6.5 and prevent the formation of zinc hydroxide.

The amount of catalyst employed will depend upon the amount of crosslinking agent. However, amounts ranging from about 0.5 to 5 weight percent (OWS) is a good practice for the thermosetting crosslinking agents. Amounts ranging from about 0.1 to 2.0 weight percent (OWS) cause satisfactory results to be obtained with the thermoplastic resins. The self-crosslinking acrylics do not require an additional catalyst, but as noted above, require a "cure" for crosslinking to occur. 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, dyes, lower alkyl alcohols, such as ethyl and isopropyl alcohols, methyl ethyl ketone, dimethyl formamide, and other commonly used finish modifiers. The reactive dyes discussed in the examples serve to color the fibers and also serve to identify the percentage add-on, thus simplifying the blending of the treated fibers having varying types of resins or different add-ons.

A typical example useful in the practice of this invention comprises 12 weight percent dimethylol dihydroxy ethyleneurea, 0.2 weight percent wetting agent, 1.0 weight percent dye, 3.0 weight percent alcohol methyl ethyl ketone, dimethyl formamide, and the like, and the balance water, all percentages (OWS).

Typical wetting agents are ethyl, methyl, and isopropyl alcohols; nonionic agents such as alkylaryl polyether alcohols, alkylaryl polyglycols, and the like.

Typical dyes are optical whiteners, and reactive dyes such as Reactive Red 12, Reactive Violet 2, Reactive Yellow 6, Reactive Blue 5, and the like.

Typical softening agents are polyethylene, polypropylene, and the nonionic fatty ester-amides. These auxiliary agents are not limiting features of this invention.

Treating the cotton fibers

Cotton fibers, preferably scoured and bleached, are passed into, and through, the aqueous bath comprising the treating agent and catalyst. The fibers may be in form of a picker-lap enclosed (encased) in scoured and bleached cotton gauze. The gauze tends to hold the lap in position and simplifies the treating operation. We prefer the use of a 13 oz./yd. picker-lap, encased in scoured and bleached 20 x 24 count cotton gauze but this method is not a limiting feature of this invention.

A period of dwell (residence time) in the aqueous treating bath is maintained for sufficient time to permit the aqueous solution to wet, and for the thermosetting resins to penetrate, the individual fibers. Excess treating solution is then removed by use of a centrifuge, or padder rolls. We prefer the latter. It is a critical feature of our invention that the fibers have a wet pickup of about 85 to 110 weight percent (OWF) of the aqueous crosslinking solution, and it is within the scope of our invention to give the fibers more than one pass through the aqueous treating bath and squeeze rolls to ensure that the proper pickup is achieved.

When the cellulosic fibers are unscoured, the use of one or more of the wetting agents listed above aids in reducing the time required for wetting and/or penetrating the fibers by the aqueous solution. However, for scoured, or scoured and bleached cellulosic fibers wetting agents are not critical features of this invention.

Drying the treated fibers

The wet fibers are then dried. We have found that drying in a continuous festoon-type drying oven is a good practice. It is a critical feature of the drying step that the air temperature of the oven be no greater than about 200° F. to prevent premature crosslinking of the cellulosic material. This is particularly important for crosslinking agents of the thermosetting type.

It is another critical feature of this invention that the moisture content, during heat drying, be reduced no lower than about 10 to 12 weight percent (OWF).

Equilibration

The treated fibers are then equilibrated, i.e., are exposed to ambient room temperature and humidity conditions for a period of time during which the moisture content of the treated fibers is further reduced to about 5.5 to 8 weight percent (OWF). After equilibration, the treated fibers are flexible, pliable, and may be readily processed on the equipment used in conventional cotton systems. This equilibration step is a critical feature of this invention. Overdried fibers may, and often do, break during further processing on conventional cotton systems and the resulting yarns and/or fabrics are commercially unacceptable. The equilibrated fibers may contain from about 1 to 20 weight percent (OWF) dry crosslinking agent based on the total weight of fiber and add-on, the exact amount depending upon the ultimate end-use of the fabric into which the blends are to be processed.

The precedure for impregnating untreated cellulosic fibers with a thermoplastic crosslinking agent is generally similar to the procedure for the thermosetting crosslinking agents, using the suggested catalyst for the thermoplast. It is an advantage in the process of our invention that the aqueous solutions of the two types of resins may be applied separately, or applied together. As noted above, some thermoplastic crosslinking agents do not require a catalyst.

Treatment of the cellulosic fibrous materials with aqueous solutions of these essentially monomeric crosslinking resins, and drying at temperatures not greater than 200° F. imparts *latent* crosslinking properties to the treated fiber, and when it is subsequently cured, either in the form of yarns, fabrics, or after the fabric has been converted into garments, the cured products have retained their fiber-and-yarn mobility. These cured products show excellent resistance to abrasion.

Blending treated and untreated fibers

Three general types of blends may be obtained: (a) blends of fibers treated with thermosetting resins and untreated fibers; (b) blends of fibers treated with thermoplastic resins and untreated fibers; and (c) blends of both (a) and (b) with untreated fibers.

When only a single type of crosslinking agent is used in preparing the blend (that is, thermosetting or thermoplastic) from about 10 to 90 weight percent of the treated fiber may be used with about 90 to 10 weight percent untreated fiber. This is true for treatments with both thermosetting crosslinking agents and with thermoplastic crosslinking agents. However, it is a critical feature of the process of this invention that there is always a *blend consisting of treated and untreated cellulosic fibers.* The presence of the untreated fibers plus fibers treated in our novel way permit *fiber and yarn* mobility in the composite yarn and/or fabric. It is this fiber-and-yarn mobility which improves the resistance to abrasion of the crosslinked products made by our novel process. This mobility is present in the yarns, the fabrics, or the products made from the fabrics, during the processing steps and *is retained after the curing, or crosslinking, step. This was unexpected.*

As noted above, it is within the scope of our invention to use fibers treated with a thermosetting resin along with fibers treated with thermoplastic resin, and untreated fibers in the blend, the blend subsequently to be processed into a yarn. When these three fibers (two treated and one untreated) are used, we prefer to use at least 10 weight percent (OWF) of the untreated fibers. The ratio of fibers treated with a thermosetting resin to fibers treated with a thermosplastic resin may vary from about 10 to 90 weight percent. In a typical example of a blend of this type, the yarn might contain 10 weight percent untreated fibers, and 45 weight percent of each type of treated fibers. However, the particular ratio of the two types of treated fibers is not a limiting feature of the present invention, good results having been obtained when each of the three types of fibers is present in equal amounts, circa 33.3 weight percent.

When the type of blend and the desired amount of each fiber in the blend have been determined, the next step is to process these blends into yarns and/or fabrics.

It is also a critical feature of this invention that the particular resin employed is a "delayed cure" type which under ambient conditions of temperature and pressure permits the user to defer curing until convenient for his purposes. "Deferred" or "delayed cure" as intended herein means that the chemical reaction between the crosslinking aganet and the cellulose (for thermosetting resins) or the crosslinking between the molecules of the thermoplastic resins will not be completed in less than one week, preferably one to six months, at ambient room temperature and humidity.

Processing the blends

It is an advantage of the process of our invention that the blends may be processed by conventional cotton systems.

The treated fibers in the form of a picker lap (as noted above) are formed into sandwich-type layers with untreated fibers and again passed through the picker, then through the card, drawing frames, roving frames, and finally spun into yarns. They are then woven into fabrics, and when desired, given a heat treatment (or cure) at about 240 to 350° F. for 20 to 3 minutes (or appropriate time intervals dependent on temperature) to complete the crosslinking between the treating agent and the cellulose. If, however, the fabric is to be converted into garments, or other cellulosic products, the cure is *delayed* until the garment, or other product has been fabricated. This will be discussed below.

It is also within the scope of our invention that the cellulosic fibers are treated in bulk form with the aqueous solution of crosslinking agent. When this procedure is used, the treated, dried, and equilibrated fibers are fed through the picker to form a picker-lap, then formed into the sandwich with the untreated fibers and again passed through the picker, card, drawing frames and spun into yarns as above. These yarns may be cured, or the uncured yarns are then woven into fabrics and may be cured in fabric form. Or the cure may be *delayed* until the garment or other cellulosic product is manufactured from the uncured fabric.

It is also within the scope of this invention to pass the treated or untreated fibres through the card to form a card sliver of each and then blend the two slivers at the drawing frame. Or, the treated and untreated sliver may be blended at the drawing frame and a second treated fiber, in the form of card sliver, may also be blended with the first two at the drawing frame. The particular machine on which the blends are formed is not a limiting feature of this invention.

It is an advantage of this invention that the proportion of treated fibers and their resin add-on can be varied at will depending upon the properties desired in the end product. For example, 50 parts (percent) treated cotton fibers may be blended with 50 parts (percent) untreated, scoured and bleached cotton fibers at the picker. This of course gives 100 parts of 50% treated and 50% untreated. In another example, 25% treated fibers may be blended with 75% untreated fibers at the picker; or 50% treated fibers may be blended with 50% untreated fibers at the picker after which three card sliver ends of this 50–50 blend may be blended with three card sliver ends of 100% treated fibers resulting in an overall blend of 75% treated fibers and 25% untreated fibers; or, 50 parts untreated cotton fibers may be blended with 50 parts thermosetting resin-treated fibers at the picker (a 50–50 blend) and then four ends of this 50–50 blend is blended with two ends of 100% thermoplastic-resin-treated cotton fibers resulting in an overall blend consisting of one-third thermoplastic-treated fibers, one-third of thermosetting-treated fibers and one-third of untreated fibers. In any of the above blends, the resin add-on may range from about 1 to 20 weight percent of the crosslinked-treated fibers. The object here is to use the particular resin add-on and blend to produce the desired properties of crease retention, flat drying, resiliency, wash-wear, and greatly increased abrasion resistance. The above slivers (drawing slivers) are then converted into roving, which in turn is converted into yarn using conventional cotton procedures. The yarns may then be cured, or the uncured yarns may be woven or knitted into fabrics and cured. Or the uncured fabrics may be converted into garments and the like, preformed by molding or creasing as desired, after which the preformed product is cured. The resultant cured product retains its formed shape. The weaving or knitting involves no deviation from normal weaving or knitting procedures.

The process is simple and easily applied, and very little, if any, mechanical processing difficulties are encountered. The products of this invention have successfully withstood up to 40 home washing-tumble drying cycles according to the procedure 88A 1964T of the American Association of Textile Chemists and Colorists, whereas control fabrics which were treated with the same resins by a padding technique (impregnating) to give comparable resin add-ons showed excessive abrasion damage after less than 10 such laundering cycles. Further, fabrics containing blends of treated-untreated fibers in both warp and filling had excellent flat drying properties, crease retention, resiliency, and showed only a minimum of abrasive damage after the 40 home washing-tumble drying cycles.

The following examples are set forth by way of illustration only, and it will be understood that the invention is not to be construed as limited in spirit or scope by the details therein. Temperatures are given in degrees Fahrenheit unless otherwise noted. All parts are percentages are by weight. 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). The crosslinking agent is frequently referred to below as the "chemical" or synthetic resin.

Wash-tumble dry: AATCC Test Method 88A–1964T
Flex abrasion: ASTM Test Method D 1175–64T
Flat abrasion: ASTM Test Method D 1175–64T
Tearing strength: ASTM Test Method D 1424–63
Wrinkle recovery: ASTM Test Method D 1295–60T

Example 1

The following example illustrates the effect of different levels of thermosetting resin add-on on the performance of cotton garments with regard to flat drying properties, crease retention, and resistance to abrasion.

(A) As the starting material, commercially scoured and bleached medium staple cotton fibers are used. These fibers are processed into 13 oz./yd. picker lap, and for ease of handling for chemical processing, the lap is encased in scoured and bleached 20 x 24 count cotton gauze.

(B) Three treating solutions are prepared using as the crosslinking agent dimethylol dihydroxy-ethylene urea.

All ingredients are parts by weight based on the total weight of the solution.

	Bath No. 1	Bath No. 2	Bath No. 3
Dimethylol dihydroxy-ethylene urea	10	14	20
Catalyst [1]	0.67	0.94	1.34
Wetting agent [2]	0.2	0.2	0.2
Ethyl alcohol	3.0	3.0	3.0
Reactive Red 12	1.0		
Reactive Yellow 6		0.5	
Reactive Blue 5		0.5	
Reactive Blue 5			1.0
Water to 100 parts.			

[1] Metallic salt complex containing zinc stabilized with acetic acid.
[2] Trimethyl nonyl ether of polyethylene glycol.

(C) The encased picker laps from (A) above are fed into a laboratory padder containing the solutions described in (B) above at the rate of about 0.75 yard per minute and passed twice (two dips and two nips) into and through the aqueous solution of crosslinking agent over a 2.3 minute period of time. A wet pickup of 95% is achieved from the 10% and the 20% solids solutions, and a wet pickup of 86% from the 14% solids solution. The padded cotton is then dried in a continuous festoon-type drying oven at a temperature not exceeding 200° F., with care being taken to dry the treated cotton to about 10–12% moisture. The balance of the water is then removed by equilibration overnight (about 15 hours). After equilibration, the treated samples contain 8.8% dry chemical add-on, 12.1% dry chemical add-on, and 18.1% dry chemicall add-on, respectively.

(D) Portions of the equilibrated but uncured treated cotton fibers from (C) above, still in lap form, are then sandwich-blended with (1) an equal weight of scoured and bleached fibers also in lap form, and (2) one-third of their weight of scoured and bleached fibers in lap form, then processed through a picker to produce picker laps of about 13.7 ounces per yard. The lap containing 50–50% treated-untreated fibers, and the lap containing 75–25% treated-untreated fibers, and a control lap containing only scoured and bleached untreated fibers, are then individually processed on a Crosrol-Varga metallic card at a cylinder speed of 240 r.p.m., a lickerin speed of 600 r.p.m., and a production rate of 10 pounds per hour in the form of 47.0 grains/yard sliver. A blend containing 25% treated and 75% untreated fibers is made by feeding three ends of the 50–50% sliver and three ends of the untreated fiber sliver to the drawing frame. Each lot is drawn twice, with the final product being 45 grains/yard second drawing sliver. A 3.8 hank roving having a 1.3 twist multiple (TM) is then produced and spun into 30/1 yarn using a 3.5 TM. These yarns are then woven into a 64 x 112 filling face sateen using a starch sized warp of untreated, unscoured, and unbleached cotton fibers. The ratio of filling weight to warp weight is 1.75 to 1 for all sateens.

(E) Simulated trouser cuffs are then made from the fabrics produced in D above with the crease for the trouser cuff in one case running in the warp direction, and in the other in the filling direction. After fabrication, the trouser cuffs are cured for 10 minutes at 320° F. (delayed-cure) after having been hand ironed to flatness and to insert the leg creases. The trouser cuffs are then evaluated for their resistance to abrasion by subjecting them to 60 wash-wear launderings, each loundering consisting of one washing and one drying cycle. The wash cycle in a home-type washer lasts seven minutes and is followed by a cold rinse, a warm rinse, and a spin-dry cycle using AATCC Test Method 88A–1964T with an 8-pound load. Soap used is 75 cc. of detergent (Tide) with a high-water setting (17 gallons). The drying cycle is 65 minutes in a home-type, electrically-heated tumble dryer. Both the washer and dryer meet the American Association of Textile Chemists and Colorists requirements for wash-tumble dry evaluation of resin-treated fabrics or garments.

(F) the simulated trouser legs are then examined after 2, 5, 8, 10, 12, 15, 18, 20, 23, 25, 28, 30, 33, 35, 38, 40, 43, 45, 48, 50, 55, and 60 launderings. Trouser creases are best when made parallel to warp direction on the fabric, and cuff creases best when trouser leg is made parallel to the filling direction. In each of these two cases, the better results are to be expected because the creases are actually being placed in the treated fibers of the filling yarn and not in the untreated warp yarn. As the chemical (resin) add-on of the treated fiber fraction increases, the abrasion due to washing and drying tends to increase, particularly where the percentage of treated fibers in the filling is high. Flat drying properties are improved with increasing chemical add-on. In no case is any abrasion damage noted before 35 wash-dry cycles, and at the 8.8% chemical add-on level for the treated fibers only some suspicious spots are evident after 60 laundry cycles. At the 18.1% chemical or resin add-on level, all samples demonstrate progressively increasing abrasive wear from 35 through 60 cycles of laundering, with some crease wear evident after 48 laundry cycles. In general, we found that a chemical add-on of about 12% in 50% of the filling fibers (4.53 weight percent resin add-on by nitrogen analysis on the total weight of the fabric) result in a product that has the best wash-wear characteristics of crease retention, flat drying, and resistance to abrasive damage during washing and tumble drying.

EXAMPLE 2

The following example illustrates the effect of the percentage of treated fibers on the performance of the finished products with regard to abrasion resistance, crease retention, and flat drying properties.

(A) A portion of the same scoured, bleached, and untreated cotton fibers used in Example 1 are used in Example 2, and the picker lap is processed in the same manner after encasing it in 20 x 24 count gauze.

(B)

	Bath No. 1	Bath No. 2	Bath No. 3
Dimethylol dihydroxy-cyclic ethylene urea	9	14	20
Catalyst [1]	0.60	0.94	1.34
Wetting agent [2]	0.2	0.2	9.2
Ethyl alcohol	3.0	3.0	3.9
Reactive Red 12	1.0		
Reactive Yellow 6		0.5	
Reactive Blue 5		0.5	
Reactive Blue 5			1.0
Water to 100 parts.			

[1] Metallic salt complex containing zinc stablized with acetic acid.
[2] Trimethyl nonyl ether of polyethylene glycol.

(C) The encased picker laps from (A) above are impregnated in the aqueous solution using a laboratory-scale padder and the procedure of Example 1. The impregnated cotton is then dried in a continuous festoon-type drying oven at a temperature of 200° F. with a residence time of 25 minutes. Moisture content of the dried cotton is held to a 10% minimum. The treated products are then equilibrated overnight. After equilibration, the samples show a 7.0% dry resin add-on, a 12.1% dry resin add-on, and an 18.1% dry resin add-on, respectively, which indicates that the wet add-on of chemical treating solution varies between 86 and 95% for these three treatments.

(D) Portions of the equilibrated but not cured treated cotton fibers from (C) above and still in lap form are sandwich-blended with (1) an equal weight of untreated, scoured, and bleached fibers also in lap form on the apron of the picker and processed into a 13.7 oz./yd. blended picker lap containing 50% treated and 50% untreated fibers at each of the three levels of crosslinking chemical add-on; and (2) one-third of their weight of untreated, scoured, and bleached fibers in picker-lap form on the apron of the picker and processed into 13.7 oz./yd. picker

laps containing 75% treated fibers and 25% untreated fibers at each of the three levels of chemical add-on. The lots of each treatment at each of the three chemical add-on levels and the two blending levels are then carded on a Crosrol-Varga metallic card at a cylinder speed of 240 r.p.m., a lickerin speed of 600 r.p.m., and a production rate of 10 pounds per hour in the form of 47.0 grains per yard sliver. A lap of the control scoured and bleached fibers is also processed through the Crosrol-Varga card under the same conditions as the laps containing blanded amounts of treated and untreated fibres. Each of these lots of fibers are then drawn twice using six ends of sliver each time and a drawing sliver of 45 grains/yd. is produced. A blended sliver containing 25% treated fibers and 75% untreated fibers is produced by feeding three ends of the 50–50% blend and three ends of the untreated, scoured, and bleached sliver to the drawing frame. After the second drawing, a sliver of 45.2 grains/yd. is produced. Each of these lots of blended sliver are processed into 3.8 hank roving having a 1.3 TM, and then spun into 30/1 yarns using a 3.5 TM, and the resulting yarns are woven into a 64 x 112 filling face sateen using a starch sized warp which consists of untreated, unscoured, unbleached cotton fibers.

(E) Simulated trouser legs and cuffs are then made from the fabrics from (D) above with the pattern so placed that two trouser legs are cut in the warp direction, and two in the filling direction from each experimental fabric. After fabrication into these simulated trouser legs and cuffs, the samples are ironed using a hand electric iron, set at the cotton setting, into flat surfaces, and creases are placed at the desired points. The pressed or ironed samples are then cured at 320° F. for 10 minutes. The cured simulated trouser legs with cuffs are evaluated for their resistance to abrasion by subjecting them to 60 wash-wear washing-and-drying cycles using home-type washing and drying equipment. This procedure and wash cycle and drying cycle are identical with those described in Example 1.

(F) The simulated trouser legs were examined at the same intervals as in Example 1. It was observed that the flat drying properties increase with increasing amounts of treated fibers present, and that the pilling of the fabric decreases with increasing amounts of treated fibers. Crease retention improves with increasing amounts of treated fibers. Creases in the leg portion of the trouser are best when the pattern is cut so that the creases are parallel with the warp of the fabric. Cuff crease retention and appearance is best when the pattern is cut so that the creases and flat surfaces are made parallel to the filling direction of the fabric. In these two cases, this phenomena would be expected since the warp is untreated and contributes little to either flat-drying properties or to the crease-retention characteristics of the fabrics. In no case is significant abrasion damage due to washing and drying noted before 35 wash-dry cycles, and then only at the lowest and intermediate levels of blends, i.e., those containing 25% and 50% treated fibers, respectively. When the treated fiber content is 75% in the filling, all samples demonstrated some abrasive damage, progressively increasing from 35 through 60 cycles with some crease-wear evident after 48 cycles when the chemical add-on is 18.1% in the treated fraction of the fibers, with substantially less evident abrasive deterioration at the 50% treated fiber fraction and below. In general, where the chemical add-on is about 12%, and the treated fraction of the fibers amounts to 50%, the product performance is best in terms of flat drying characteristics, resistance to pilling, crease retention, and reduced abrasion damage during multiple wash-dry cycles of simulated usage.

When the above example is repeated using dimethylol hydroxyethyl carbamate, or bismethoxymethyl ethyl carbamage, or vinyl cyclo hexene diepoxide instead of the dimethylol dihydroxy cyclic ethyleneurea, generally similar results are obtained.

Example 3

This example illustrates the beneficial effects of having both thermoplastic and thermosetting resinous treatments on separate fractions of the fibers going into blends to improve product performance in such characteristics as flat drying, crease retention, and resistance to abrasion such as occurs during washing and drying using home-type laundry equipment.

(A) Portions of the same scoured and bleached raw-stock cotton fibers used in Example 1 are used and processed as in Example 1.

(B) A treating solution is prepared using a thermoplastic self-crosslinking acrylic resin as follows:

	Bath No. 1
Self-crosslinking acrylic resin [1]	10.0
Wetting agent [2]	0.2
Ethyl alcohol	3.0
Reactive Yellow 6	1.0
Water to 100 parts.	

[1] Aqueous acrylic dispersion of thermoplastic resin—HA–20 sold by Rohm & Haas.
[2] Trimethyl nonly ether of polyethylene glycol.

(C) The crosslinking chemical is applied to the cellulosic fiber by the procedure of Example 1 using a laboratory-scale padder with two dips and two nips with the feed rate set at 0.75 yd. per minute, and a residence time (period of dwell) in the padder of 2.3 minutes. From the padder the treated picker lap is fed into a festoon type continuous dryer and held at 200° F. for approximately 25 minutes. After equilibrating overnight, the treated fiber analyzes 2.8% acrylic resin add-on by the method of Kanter and Hoey, American Dyestuff Reptr. 52 (14) 515–516, July 8, 1963.

(D) Because some adherence between fibers is observed after the acrylic treated fibers are equilibrated overnight they are then passed through a laboratory-scale cotton opener, through a willow, a downstroke, a second opener, and thence into the picker to be formed into 16 oz./yd. lap which is then carded on the Crosrol-Varga metallic card into 47 grain/yd. sliver. Two ends of this sliver are then fed into the drawing frame along with four ends of the blend containing 50% of fibers treated with an 8.8% add-on of dimethylol dihydroxy ethyleneurea (fibers from Bath A—Example 1) and then drawn twice to produce a 45 grain/yd. second-drawing sliver which consists of 33.3% fibers treated with dimethylol dihydroxy ethyleneurea at the 8.8% add-on level, 33.3% fibers treated with the self-crosslinking acrylic dispersion at the 2.8% level, and 33.3% untreated, scoured, and bleached fibers. Similar procedures are used in the production of blends in sliver form consisting of 33.3% dimethylol dihydroxy ethyleneurea treated fibers at the 12.1 and at 18.1 levels (Baths B and C of Example 1) with 33.3% of the acrylic treated fibers and 33.3% untreated scoured and bleached fibers, and the resulting sliver weighs 45 grains per yard. These slivers are then processed into 3.8 hank roving using a 1.3 TM, then into 30/1 yarns with 3.5 TM, and then woven into a 64 x 112 filling face sateen using a starch sized warp of untreated, unscoured, and unbleached cotton fibers.

(E) Simulated trouser legs and cuffs are then made from fabrics from (D) above with the pattern so placed that two samples may be cut in the warp direction of each fabric, and two in the filling direction of each fabric. After the simulated garments are made they are hand ironed with a home-type electric iron set at the cotton setting to obtain flat surfaces and creases where desired. Following ironing the samples are cured at 320° F. for 10 minutes. (As noted above, the self-crosslinking acrylics require a "cure" at temperatures of at least 240° F.) The cured simulated trouser legs and cuffs are then evaluated for their resistance to abrasion such as occurs in laundering by subjecting them to 60 wash-wear cycles of washing followed by tumble drying in a home-type washer and

dryer. The procedure and drying time temperatures of Example 1 are followed.

(F) The samples were examined visually for signs of abrasion damage at the same intervals as described for Example 1. We found that the presence of the thermoplastic treated fibers in the yarns significantly improved the appearance and the resistance of the samples to abrasion damage during washing. None of the samples containing the thermoplastic treated fibers in addition to the thermosetting treated fibers exhibited any abrasion damage either in the cuff area or in the creases, after the samples had been subjected to 60 wash-dry cycles. As previously observed in Examples 1 and 2, the creases in the leg portion of the samples are considerably better when the pattern is cut so that these creases fall parallel to the warp than when the pattern is cut so that the creases are parallel to the filling. The obvious explanation for this observation is that when the creases are parallel to the warp, the treated fibers in the filling yarns are being creased; and when the crease is parallal to the filling, untreated fibers are being creased since the warp yarns are untreated. The opposite should hold for the cuffs due to the direction in which they are folded at 90° to the crease in the trouser leg. This, too, is confirmed by direct observation of the samples. Improved flat drying characteristics and improved crease appearance accompanied the increase in the thermosetting chemical add-on, although there is an indication that very satisfactory performance in these two properties can be obtained at add-ons as low as 8.8% in the thermosetting treated fiber part of the blend. This results then in the average add-on for the fabric expressed in terms of thermosetting resin of 1.02% and an average resin add-on in terms of thermoplastic resin of 1.17%. Much reduced pilling is noted when the thermoplastic resin is present in the fabrics.

Example 4

This example illustrates the beneficial effects in such properties as flat drying, crease retention, tensile strength, and resistance to abrasion damage of having both the warp and the filling composed of a blend of resin treated and untreated cotton fibers.

(A) Portions of the same scoured and bleached cotton rawstock used for Example 1 encased in gauze are processed by the mechanical procedure of Example 1.

(B) The treating solution in this example consists of a 13% resin solids concentration of dimethylol dihydroxy ethyleneurea, 0.27% of alkylaryl polyglycol, 3.25% ethyl alcohol, 0.5% zinc nitrate complex catalyst, 1% Reactive Brown dye, and 81.96% water.

(C) The untreated fibers (picker lap) are then passed into, and through, the aqueous solution of (B), using the laboratory-scale padder described in Example 1, with the same feed rate and residence time and with the wet pickup controlled to about 86%. The wet picker lap is then passed through the festoon type dryer under the same conditions as described in Example 1. After equilibrating overnight, the treated fibers analyzed 10.4% resin content.

(D) Approximately 45 pounds of the treated lap are sandwich blended at the apron of the picker with an equal amount of untreated but scoured and bleached cotton fibers in the form of picker lap, then processed to produce picker laps of about 13.5 oz. per yard. Similarly, about six pounds of the treated lap are sandwich blended at the apron of the picker with about two pounds of untreated, scoured, and bleached picker lap and processed into 13.6 oz. per yard picker laps which yields a blend having 75% treated and 25% untreated fibers. These two blends are then individually carded on a (Crosrol-Varga) metallic clothed card at a cylinder speed of 240 r.p.m., a lickerin speed of 600 r.p.m., and a production rate of 10 pounds per hour in the form of 45 grains/yd. sliver.

A portion (82 pounds) of the blend containing equal weights of treated and untreated fibers in card sliver form are then drawn twice, feeding six ends each time to assure even more intimate blending of the fibers in the final drawn sliver which weighs 45 grains per yard. This is designated "Blend A." The remaining eight pounds of the equal-weight blend of treated and untreated fibers are then reduced to a 25% treated fiber and 75% untreated fiber blend by feeding three ends of the 50% treated fiber, 50% untreated fiber card sliver, and three ends of 45 grain sliver previously made from the scoured and bleached rawstock which has not been treated. These ends are fed through the drawing frame twice and the resulting drawing sliver weighs 45 grains per yard. This is designated "Blend B."

The blend containing 75% treated fibers and 25% untreated fibers is drawn twice, feeding six ends on each pass to the drawing frame. The resulting sliver weighs 45 grains per yard and is designated "Blend C."

From each blend, roving is produced, which, in turn, is processed in several different ways:

(a) to produce a warp, about 75 pounds of Blend A are spun into 50/1 yarns having a 4.25 TM which are doubled or plied into a 50/2 yarn, creeled and wound onto a warper reel, and thence onto a suitable warp beam. The ends are then drawn into 10 harnesses which permit the weaving of a three up two down twill fabric.

(b) Another portion of Blend A, weighing about six pounds, is spun into 13.5/1 yarn having a TM of 3.5. This is then used as filling yarn.

(c) Blend B is spun into 13.5/1 yarns having 3.5 TM and are used as filling yarns.

(d) Blend C is spun into 13.5/1 yarns having 3.5 TM and are used as filling yarns.

(e) A control yarn is produced from the untreated, scoured, and bleached rawstock from which the treated blends are made, and it, too, is spun into 13.5/1 yarn with a 3.5 TM and is used as filling yarns.

Weaving is carried out on a standard cotton loom at the rate of 165 picks per minute, producing fabrics having 126 ends per inch and 50 picks per inch (126 x 50). In this manner, fabrics made from the yarns produced from blends A, B, C, and the untreated control yarns, and the resulting fabrics contain a warp which is composed of 50% treated and 50% untreated cotton fibers, the treated portion of which has a chemical add-on of 10.4% thermosetting resin. The fillings in each case contain treated fibers in the amount of 50% for Blend A, 25% for Blend B, and 75% for Blend C, and the chemical add-on of the treated fiber portion is 10.4%. The control yarn filling, of course, contains no chemically treated fibers.

(E) Simulated trouser legs, 11⅝ inches long by 9⅝ inches wide with a 1⅝ inch cuff, are then made from the fabrics produced in (D) above, with the crease for the trouser leg, in one case, running in the warp direction, and, in another case, in the filling direction. After fabrication, the experimental sample trouser legs and cuffs are pressed on a commercial-type steam press with the steam on for four seconds, with head pressure of 90 pounds steam, and a holding time of 11 seconds. Temperature of pressing is 320° F. Immediately following pressing, the samples are placed in a gas-fired cabinet-type oven and cured at 320° F. for eight minutes. All samples are then equilibrated for at least 24 hours before any physical testing is done.

Performance evaluation of the fabrics from which the above simulated trouser legs were made are carried out using laboratory test equipment, such as the Stoll flex and flat abrasion tests, tear strength test, and others. In addition, the cured trouser leg samples are subjected to 40 wash-tumble dry cycles in a commercially available home-type washing machine and a commercially manufactured home-type electric dryer, each of which meets the AATCC test method 88A 1964T. Each four-pound batch of these samples is washed with 75 cc. of a commercial detergent in each wash cycle along with high water level. The washing period is eight minutes and is

followed by a cold rinse and spin dry. The tumble drying cycle requires 60 minutes. The test results with regard to abrasion damage on these samples were extremely good. The following generalized observations can be made for the samples containing blends of treated and untreated cotton fibers in both warp and filling:

(a) The crease retention in the leg portion of the samples was gas, regardless of the direction in which the pattern was cut.

(b) The cuff appearance (crease and shape retention) was good, regardless of the direction in which the pattern was cut.

(c) No pilling was observed on the samples at any of the levels of add-on evaluated, nor at any of the percentages of treated fibers considered.

(d) Flat drying properties were good regardless of the direction in which the pattern had been cut; however, the samples cut in the warp direction exhibited some puckering of cuff bottoms after five laundering cycles.

(e) Some seam pucker was noted in samples cut in the filling direction, while no seam pucker was noted in the samples cut in the conventional warp direction.

(f) More wear, due to abrasive damage, was apparent in samples that had been cut in the conventional warp direction than in the samples that had been cut in the transverse or filling direction. Very few of the samples showed any abrasive damage prior to the 30th wash-tumble dry cycle.

(g) About 2% shrinkage was observed in the conventional warp direction samples. This shrinkage occurred in both the warp and filling directions of the fabric.

(h) Physical test data based on laboratory tests were as follows:

	Resin, wt. percent	Flex abrasion		Flat abrasion	Tearing (grams)		Wrinkle Recovery
		Warp	Fill		Warp	Fill	Warp+Fill[1]
Sample containing treated warp+Blend A in filling	5.5	721	304	359	1,967	1,767	255
Sample containing treated warp+Blend B in filling	4.3	789	1,122	394	1,700	567	249
Sample containing treated warp+Blend C in filling	6.6	668	89	336	1,767	1,400	267
Sample containing untreated warp and untreated filling		983	1,607	551	2,833	3,833	194
Sample containing treated warp+untreated filling	3.4	794	1,428	337	1,533	3,867	236

[1] A warp+fill angle of 240 is considered satisfactory for wash-wear fabrics.

Example 5

In this example, the performance characteristics of five fabrics, impregnated with the same crosslinking agent by the conventional padding procedure, are compared with the fabrics of Example 4. In this example, a 3/2 twill is made which contains scoured and bleached filling, and scoured and bleached warp yarns.

The fabrics are subjected to a padding operation consisting of two dips and two nips in a pilot-scale padder with the final squeeze roll pressure adjusted to give a product having about 80% wet add-on.

For fabric FA.—The treating solution bath contains:

10% dimethylol dhydroxy ethyleneurea, 0.25% alkylaryl polyglycol, 3.75% ethyl alcohol, 0.5% zinc nitrate complex catalyst, 1% scarlet dye, and 84.50% water. From the final nip, the fabric was passed through a tender and dried at 185° F. to approximately 12% moisture content, then equilibrated for 24 hours before use. Chemical add-on calculated from nitrogen analysis was 9.55%.

For fabric FB.—The treating solution contains:

8.25% dimethylol dihydroxy ethyleneurea by weight, 0.25% alkylaryl polyglycol, 3.75% ethyl alcohol, 0.45% zinc nitrate complex catalyst, 1% turquoise dye, and 86.75% water. From the final nip, the fabric was passed through a tenter frame and dried at 185° F. to approximately 12% moisture content, then equilibrated for 24 hours before use. Chemical add-on of this fabric calculated from nitrogen determination was 8.34%.

For fabric FC.—The treating solution contains:

6.25% dimethylol dihydroxy ethyleneurea, 0.25% alkylaryl polyglycol, 3.75% ethyl alcohol, 0.35% zinc nitrate complex catalyst, 1% red dye, and 88.40% water. From the second nip, the fabric was passed through a tender and dried at 185° F. to approximately 12% moisture content, then equilibrated for 24 hours prior to use. The chemical add-on of this fabric calculated from a nitrogen determination was 6.80%.

For fabric FD.—The treating solution consisted of:

5% dimethylol dihydroxy ethyleneurea, 0.25% alkylaryl polyglycol, 3.75% ethyl acohol, 0.30% zinc nitrate complex catalyst, 1% dark red dye, and 89.70% water. From the final nip, the fabric was passed through a tenter and dried at 185° F. to a moisture content of approximtaely 12%, then equilibrated for 24 hours before use. Chemical add-on of this fabric calculated from a nitrogen determination was 5.70%.

For fabric FE.—The treating solution consisted of:

3.75% dimethylol dihydroxy ethyleneurea, 0.25% alkylaryl polyglycol, 3.75% ethyl alcohol, 0.25% zinc nitrate nitrate complex catalyst, 1% orange dye, and 91.00% water. From the final nip, the fabric passed through a tender and was dried at 185° F. to a moisture content of about 12%, then equilibrated for 24 hours before use. The chemical add-on of this fabric calculated from a nitrogen determination was 4.39%.

In a manner parallel to that used in Example 4, simulated pants legs and cuffs (11⅝" by 9⅝" with 1⅝" cuffs) were made, and then pressed under the same conditions as in Example 4, and then cured under the same conditions as used in Example 4, and allowed to equilibrate for a minimum of 24 hours before testing.

Performance evaluation was made of these samples within the same laundry batches as the samples produced in Example 4, and corresponding laboratory determinations on flex and flat abrasion, tearing strength, and Monsanto wrinkle resistance were made on the fabrics from which the simulated pants legs were made.

The following are generalized observations of the samples:

(a) Crease retention in the leg portion is equally good regardless of the direction in which the pattern was cut.

(b) The cuff appearance (crease and shape retention) is good regardless of the direction in which the pattern was cut.

(c) No pilling is apparent on the samples at any of the chemical add-on levels studied.

(d) Flat drying properties are good regardless of the direction in which the pattern was cut.

(e) Very little seam pucker is noted on the samples.

(f) Abrasive damage is apparent on all samples after as few as seven laundering and tumble-drying cycles. The samples had completely worn through in spots at the leg crease after as 10 laundering tumble-dry cycles, and the cuffs exhibited holes at the top and bottom of

the crease after as few as eight laundering tumble-dry cycles.

(g) Less than 2% shrinkage is observed regardless of the direction in which the pattern had been cut.

(h) Physical test data based upon laboratory tests were as follows:

Sample Fabric	Resin, wt. percent	Flex abrasion		Flat abrasion	Tearing strength (grams)		Wrinkle recovery° Warp+Fill [1]
		Warp	Fill		Warp	Fill	
FA	9.5	14	31	285	800	1,217	293
FB	8.4	26	69	399	933	1,117	287
FC	6.8	24	74	360	933	1,183	280
FD	5.7	19	46	383	933	1,233	287
FE	4.4	53	233	530	1,200	1,900	263

[1] A warp+fill angle of 240 is considered satisfactory for wash-wear.

Example 6

In the following example, data from Examples 5 and 6 are considered to show the improvement in flex abrasion and tearing strength in fabrics produced from yarns containing blends of crosslinked fibers and untreated fibers when compared with fabrics containing similar quantities of crosslinking agents applied by present conventional processes wherein the entire fabric is impregnated.

	Resin add-on [1] wt. percent total	Flex abrasion		Tearing Str. (grams)		Wrinkle recovery° [2] W+F
		Warp	Filling	Warp	Filling	
Sample containing treated warp+Blend C in filling from Example 5	6.6	668	89	1,767	1,400	267
Fabric FC—Example 6	6.8	24	74	933	1,183	280
Sample containing treated warp+Blend B in filling from Example 5	4.3	789	1,122	1,700	2,567	249
Fabric FE—Example 6	4.4	53	233	1,200	1,900	263
Sample containing treated warp+Blend A in filling from Example 5	5.5	721	304	1,967	1,767	255
Fabric FD—Example 6	5.7	19	46	933	1,233	287

[1] Resin add-on was determined by nitrogen analysis.
[2] A warp+filling wrinkle recovery angle of 240° is considered satisfactory wash-wear fabrics.

It will be observed that in all cases there is a sharp reduction in flex abrasion and tearing strength for the same resin add-on where the fabric is treated by conventional padding processes.

We claim:

1. A process for producing yarn from a blend of untreated cellulosic fiber and resin-treated cellulosic fiber in which resin-treated fiber the resin has not been cured, comprising
   (a) treating cellulosic fiber with an aqueous solution of a catalyst and an essentially monomeric crosslinking resin selected from the group consisting of thermosetting resins and a mixture of thermosetting and thermoplastic resins to obtain a wet pick-up of about from 85 to 110 weight percent based on the weight of the cellulosic fiber;
   (b) drying the resin-treated fiber from step (a) at a temperature below about 200° F. to obtain uncured, resin-treated cellulosic fiber at an equilibrated moisture content of about from 5.5 to 8.0 weight percent based on the total weight of the fiber and deposited resin;
   (c) blending the dried, uncured, resin-treated cellulosic fiber from step (b) with untreated cellulosic fibers; and
   (d) forming yarn from the blended fiber of step (c).

2. The process of claim 1 wherein the crosslinking resin is a thermosetting resin.

3. The process of claim 1 wherein the crosslinking resin is a mixture of thermosetting and thermoplastic resins.

4. A process for producing a crosslinked cellulosic yarn from a blend of untreated cellulosic fiber and resin-treated cellulosic fiber in which resin-treated fiber the resin has not been cured, comprising
   (a) treating cellulosic fiber with an aqueous solution of a catalyst and an essentially monomeric crosslinking resin selected from the group consisting of thermosetting resins and a mixture of thermosetting and thermoplastic resins to obtain a wet pick-up of about from 85 to 110 weight percent based on the weight of the cellulosic fiber;
   (b) drying the resin-treated fiber from step (a) at a temperature below about 200° F. to obtain uncured, resin-treated cellulosic fiber at an equilibrated moisture content of about from 5.5 to 8.0 weight percent based on the total weight of the fiber and deposited resin;
   (c) blending the dried, uncured, resin-treated cellulosic fiber from step (b) with untreated cellulosic fibers;
   (d) forming yarn from the blended fiber of step (c); and
   (e) curing the crosslinking resin in the yarn from step (d) at a temperature of about from 240° F. to 350° F. using curing times of about from 20 to 3 minutes.

5. The process of claim 4 wherein the crosslinking resin is a thermosetting resin.

6. The process of claim 4 wherein the crosslinking resin is a mixture of thermosetting and thermoplastic resins.

7. A process for preparing a wash-wear cellulosic fabric from a blend of untreated cellulosic fiber and resin-treated cellulosic fiber wherein the resin-treated moiety has not been cured to induce crosslinking, comprising
   (a) forming a fabric from yarn produced by the process of claim 1; and
   (b) curing the fabric formed in step (a) to induce a crosslinking reaction.

8. The process of claim 7 wherein the crosslinking resin used is a thermosetting resin.

9. The process of claim 7 wherein the crosslinking resin used is a mixture of thermosetting and thermoplastic resins.

10. A process for preparing a wash-wear garment from a cellulosic fabric composed of a blend of untreated cellulosic fiber and resin-treated cellulosic fiber wherein the resin-treated moiety has not been cured to induce crosslinking, comprising
   (a) forming a fabric from yarn produced by the process of claim 1;
   (b) forming a garment from the fabric of step (a); and
   (c) curing the garment formed in step (b) to induce a crosslinking reaction.

11. The process of claim 10 wherein the crosslinking resin used is a thermosetting resin.

12. The process of claim 10 wherein the crosslinking resin used is a mixture of thermosetting and thermoplastic resins.

(References on following page)

19

References Cited

UNITED STATES PATENTS

2,119,150	5/1938	Bowen et al.	
3,008,215	11/1961	Pitts	57—153 X
3,127,732	4/1964	Brown et al.	57—164
3,220,085	11/1965	Lund et al.	

5

20

GEORGE F. LESMES, Primary Examiner

J. CANNON, Assistant Examiner

U.S. Cl. X.R.

8—115.6, 116.3; 28—75; 38—144; 57—140; 153, 156, 164; 161—175