METHODS FOR IMPROVING DIMENSIONAL STABILITY AND/OR DURABLE PRESS PROPERTIES OF ELASTIC FABRICS AND ELASTIC FABRICS WITH IMPROVED PROPERTIES

Methods for providing elastic fabric comprising synthetic elastic fibers and natural fibers with improved dimensional stability or improved durable press while maintaining stretch recovery properties comprise treating the fabric with a treatment composition comprising formaldehyde and a catalyst for crosslinking the formaldehyde with natural fibers in the fabric, and processing the treated fabric to effect crosslinking of the formaldehyde and to maintain stretch performance properties. Fabrics comprising synthetic elastic fibers and natural fibers exhibiting improved dimensional stability and/or durable press properties in combination with additional advantageous properties are produced.
METHODS FOR IMPROVING DIMENSIONAL STABILITY AND/OR
DURABLE PRESS PROPERTIES OF ELASTIC FABRICS AND ELASTIC
FABRICS WITH IMPROVED PROPERTIES

FIELD OF THE INVENTION

This invention relates to methods for providing elastic fabrics comprising synthetic elastic fibers and natural fibers and having improved dimensional stability and/or durable press properties, particularly while maintaining good stretch recovery of the fabrics. This invention also relates to elastic fabrics which have improved dimensional stability and/or improved durable press properties, particularly wherein the fabrics comprise synthetic elastic fibers and natural fibers.

BACKGROUND OF THE INVENTION

Many fabrics, comprising natural fibers do not possess durable press (or "wash and wear" or "smooth-dry") performance or dimensional stability, i.e., shrinkage resistance. Cellulosic fabrics, such as fabrics containing cotton, for instance, have been treated with aminoplast resins, including N-methylol cross-linking resins such as dimethylol dihydroxyethyleneurea (DMDHEU) or dimethylol propylcarbamate (DMPC), to impart durable press properties, as disclosed, for example, in the Martin et al U.S. Patent No. 4,521,176. Unfortunately, many reacted aminoplast resins break down during storage, thus releasing formaldehyde. The formaldehyde release may occur not only throughout the preparation of the fabric but also during garment-making. Further, garments or fabrics treated with aminoplast resins may release additional formaldehyde when stored under humid conditions. Aminoplast resins may also hydrolyze during washing procedures, resulting in a loss of the durable press performance. Additionally, aminoplast resins tend to give fabric a harsher handle, that is, make the fabric feel less soft. As the resins make the fabric feel less soft, the fabric must be treated with additional softeners, for example silicone softeners. Unfortunately, the silicone softeners tend to
make the fabric hydrophobic although it is often preferred that the fabric have hydrophilic properties.

Cellulosic fibers have also been cross-linked with formaldehyde to impart durable press properties. For example, the Payet U.S. Patents Nos. 3,960,482, 3,960,483, 4,067,688 and 4,104,022 disclose durable press processes which comprise impregnating a cellulosic fiber-containing fabric with an aqueous solution comprising a catalyst, and, while the fabric has a moisture content of above 20% by weight, exposing the fabric to formaldehyde vapors and curing under conditions at which formaldehyde reacts with the cellulose. The Payet U.S. Patent No. 4,108,598 discloses a process which comprises treating cellulosic fiber-containing fabrics with an aqueous solution of formaldehyde and a catalyst, heat curing the treated fabric by introducing the fabric into a heating zone, and gradually increasing the temperature of the heating zone, thereby increasing the temperature of the heated fabric to prevent the loss of an amount of formaldehyde which will reduce the overall extent of curing. The Payet U.S. Patent No. 5,885,303 also discloses a durable press process for cellulosic fiber-containing fabrics. The process comprises treating the fabric with an aqueous solution of formaldehyde, a catalyst capable of catalyzing the cross-linking reaction between formaldehyde and cellulose, and an effective amount of a silicone elastomer to reduce loss in tear strength in the treated fabric. Formaldehyde is generally less expensive than aminoplast resins, and formaldehyde treatment of cellulosic fabrics typically results in durable press properties which are more durable than those obtained by aminoplast resins.

Many consumers also prefer garments containing synthetic elastic fibers and/or garments comprising a blend of synthetic elastic fibers and natural fibers such as, for instance, spandex blend knit and/or woven fabrics. Fabrics containing synthetic elastic fibers have the ability to be stretched repeatedly and still recover to very near their original length and/or shape. Such fabrics are often incorporated in garments which comfortably conform to the consumer's body without bagging and/or sagging. However, these fabrics often undesirably exhibit noticeable shrinking and/or wrinkling after aqueous laundering, and it is difficult to find means for overcoming the disadvantages while maintaining the desirable elastic properties of such fabrics. Additionally, the life expectancy of garments made of these fabrics is often decreased by repeated heat
treatments used during manufacturing and/or home care procedures, as combinations of heat and tension accelerate the fabric growth of elastic fabrics thereby resulting in an unacceptable fit and/or appearance.

Accordingly, there is a continuing need to further improve individual characteristics of elastic fabrics containing a blend of synthetic elastic fibers and natural fibers and to improve the overall combinations of properties exhibited by such fabrics.

**SUMMARY OF THE INVENTION**

Accordingly, it is an object of the present invention to obviate problems of the prior art. It is a further object of the present invention to provide methods for improving the dimensional stability and/or durable press properties of fabrics and particularly to improve the dimensional stability and/or durable press properties of elastic fabrics containing synthetic elastic fibers and natural fibers, while maintaining stretch recovery of the fabrics. It is a related object to provide methods for preparing elastic fabrics which exhibit advantageous combinations of properties and which are suitable for aqueous washing or laundering, and to provide elastic fabrics exhibiting such advantageous properties.

These and additional objects are provided by the methods and fabrics of the invention. In one embodiment, the invention is directed to methods for providing elastic fabric comprising synthetic elastic fibers and natural fibers with improved dimensional stability while maintaining stretch recovery properties of the fabric. The methods comprise treating elastic fabric comprising synthetic elastic fibers and natural fibers with a treatment composition comprising formaldehyde, and a catalyst for crosslinking the formaldehyde with natural fibers in the fabric, and processing the treated fabric to effect crosslinking of the formaldehyde and to maintain stretch performance properties. According to more specific embodiments, the treated fabrics are processed under controlled conditions such as, for instance, temperature, time and tension levels.

In another embodiment, the invention is directed to methods for providing elastic fabric comprising synthetic elastic fibers and natural fibers with improved durable press while maintaining stretch recovery properties of the fabric. The methods comprise treating elastic fabric comprising synthetic elastic fibers and natural fibers with a
treatment composition comprising formaldehyde and a catalyst for crosslinking the formaldehyde with natural fibers in the fabric, and processing the treated fabric to effect crosslinking of the formaldehyde and to maintain stretch performance properties. According to more specific embodiments, the treated fabrics are processed under controlled conditions such as, for instance, temperature, time and tension levels.

In yet additional embodiments, the invention is directed to fabric comprising synthetic elastic fibers and natural fibers and exhibiting a durable press value of at least about 3.0 after the fabric has been aqueous laundered one time, and to fabric comprising synthetic elastic fibers and natural fibers and exhibiting a length dimensional change and a width dimensional change of less than about 5% each after the fabric has been aqueous laundered one time.

The methods of the invention are advantageous in providing fabrics which exhibit improved dimensional stability and/or durable press properties, while maintaining stretch recovery properties.

These and additional aspects, objects and advantages of the invention are more fully described in the detailed description.

**DETAILED DESCRIPTION**

The present invention is directed to methods for providing fabrics, particularly elastic fabrics comprising synthetic elastic fibers and natural fibers, with improved dimensional stability and/or good durable press properties while maintaining stretch recovery properties. This invention also relates to elastic fabrics comprising synthetic elastic fibers and natural fibers and exhibiting good durable press and/or dimensional stability even after aqueous laundering.

As used herein, "dimensional stability" refers generally to the ability of a fabric to resist dimensional change, particularly after aqueous laundering. As employed in the present invention, improved dimensional stability indicates that the fabric exhibits a dimensional change in length and width, after the fabric has been aqueous laundered one time, less than that exhibited by the untreated fabric after one aqueous laundering.

As used herein, "stretch recovery" refers generally to the ability of a fabric to substantially recover to very near its original length and/or shape after being stretched,
particularly such that the fabric does not retain a permanent deformation. As used herein, "permanent deformation" refers generally to the ability of a fabric to retain a permanent length and/or shape after being stretched such that the fabric does not recover back to or near the original fabric dimensions exhibited prior to stretching the fabric. In one embodiment, the resulting fabrics according to the present invention exhibit a fabric growth of not greater than about 5% after the fabric has been stretched at least about 80% of its maximum stretch under a four pound load according to ASTM D 3107. As used herein, "fabric stretch" refers generally to the increase in length of a specimen of fabric resulting from a load applied under specified conditions (specified tension) and "fabric growth" refers generally to the difference between the original length of a specimen and its length after application of a specified tension for a prescribed time and the subsequent removal of the tension.

The fabrics employed in the present invention comprise synthetic elastic fibers and natural fibers. As used herein, "fiber" refers generally to a generic term for any one of the various types of matter that form the basic elements of a textile and that is characterized by having a length at least 100 times greater than its diameter. As used herein, "filament" refers generally to a continuous fiber of extremely long length, whereas a "staple" refers generally to a natural fiber of cut lengths from a filament and "tow" refers to a coarse and/or broken fiber and/or filament.

As used herein, "yarn" refers to a continuous strand of textile fibers, generally filaments, and/or materials in a form suitable for knitting, weaving or otherwise intertwining for a textile fabric. As used herein, "fabrics" generally refer to knitted fabrics, woven fabrics, or non-woven fabrics prepared from yarns or fibers, while "garments" generally refer to wearable articles comprising fabrics, including, but not limited to, shirts, blouses, dresses, pants, sweaters and coats. Non-woven fabrics include textile structures produced by bonding or interlocking of fibers, or both, accomplished by a mechanical, chemical, thermal, or solvent means and combinations thereof. "Textiles" includes fabrics, yarns, and articles comprising fabrics and/or yarns, such as garments, home goods, including, but not limited to, bed and table linens, draperies and curtains, and upholsteries, and the like.
As used herein, "natural fibers" refer to fibers which are obtained from natural sources, such as cellulosic fibers and protein fibers, or which are formed by the regeneration of or processing of natural occurring fibers and/or products. Natural fibers are not intended to include fibers formed from petroleum products. Natural fibers include fibers formed from cellulose, such as cotton fiber and regenerated cellulose fiber, commonly referred to as rayon, or acetate fiber derived by reacting cellulose with acetic acid and acetic anhydride in the presence of sulfuric acid. As used herein, "natural fibers" are intended to include natural fibers in any form, including individual filaments, and fibers present in yarns, fabrics and other textiles, while "individual natural fibers" is intended to refer to individual natural filaments.

As used herein, "thermoplastic fiber" refers generally to a class name for various genera of filament, tow, or staple produced from a fiber forming substance which is synthesized from a chemical compound.

As used herein, "cellulosic fibers" are intended to refer to fibers comprising cellulose, and include, but are not limited to, cotton, linen, flax, rayon, cellulose acetate, cellulose triacetate, hemp and ramie fibers. As used herein, "rayon fibers" is intended to include, but is not limited to, fibers comprising viscose rayon, high wet modulus rayon, cuprammonium rayon, saponified rayon, modal rayon and lyocell rayon. "Protein fibers" are intended to refer to fibers comprising proteins, and include, but are not limited to, wools, such as sheep wool, alpaca, vicuna, mohair, cashmere, guanaco, camel and llama, and silks.

As used herein, "synthetic fibers" refer to those fibers which are not prepared from naturally occurring filaments and include, but are not limited to, fibers formed of synthetic materials such as polyesters, polyamides such as nylons, polyacrylics, and polyurethanes such as spandex. Synthetic fibers include fibers formed from petroleum products. As used herein, "synthetic elastic fibers" are those fibers which form "synthetic elastic yarns", such as nontextured yarns which can be stretched repeatedly at room temperature to at least twice their original length and which after removal of the tensile force will immediately and forcibly return to approximately their original length. According to the present invention, synthetic elastic fibers include, but are not limited to, elastane fibers (i.e., Spandex). As is used herein, "spandex" and "elastane" fibers both
refer generally to manufactured fibers in which the fiber forming substance is a long-chain synthetic polymer comprised of at least 85% of a segmented polyurethane.

Elastic fabrics for use in the present invention comprise a textile product made from synthetic elastic fibers and/or synthetic elastic yarns either alone or in combination with other textile materials. Additionally, the elastic fabrics may be in the form of garments or other textiles comprising synthetic elastic fibers and natural fibers. In one embodiment, the fabrics comprise at least about 20% by weight of natural fibers, such as cotton fibers, rayon fibers or the like. In additional embodiments, the fabrics comprise from about 0.5% to about 20% by weight of synthetic elastic fibers.

While not being bound by theory, it is believed that when elastic fabrics containing natural fibers are treated with a composition comprising formaldehyde and a catalyst capable of cross-linking formaldehyde with a natural fiber, a chemical modification of the natural fibers occurs. It is believed that the formaldehyde reacts chemically with the natural fibers to cross-link the individual polymer chains of the natural fibers, thereby improving various fabric performance properties, such as for instance, durable press properties and/or dimensional stability, i.e., reduced dimensional change. Surprisingly, the elastic fabrics treated according to the present methods maintain their stretch performance properties, i.e., the fabrics remain elastic and exhibit good stretch recovery. This is surprising as one might expect that the crosslinking which provides improved dimensional stability and/or durable press would disadvantageously limit the elasticity, and specifically the stretch ability and stretch recovery properties, of the fabric. In accordance with the present methods, a silicone elastomer or precursor thereof may also be included in the formaldehyde treatment to provide additional desirable properties, for example good strength and/or tear strength, water absorbency and the like. The processes of the present invention are also advantageous in providing fabrics exhibiting reduced drying time, improved fibrillation resistance and/or pill resistance and improved brightness.

To provide the crosslinked formaldehyde treatment, the fabric is treated with a treatment composition comprising formaldehyde and a catalyst followed by drying and/or curing of the treated fabric. In a more specific embodiment, the treatment composition further comprises a silicone elastomer or a precursor thereof. Formaldehyde is generally
available in an aqueous solution, referred to as formalin, comprising water, about 37% by weight formaldehyde, and generally about 10% to 15% by weight methanol. Formaldehyde may also be generated in an aqueous treating solution in situ by adding paraformaldehyde (polyoxymethylene) to water, thereby generating formaldehyde.

The amount of formaldehyde in the treatment composition is sufficient to impart improved dimensional stability and/or improved durable press, while maintaining stretch recovery properties. In further embodiments, additional desirable properties are also provided. The amount of formalin useful for imparting the above mentioned properties according to the present invention is typically dependent upon the cellulosic content of the fabric. In exemplary embodiments, the fabric is treated with at least about 1% by weight formalin, and specifically with from about 2% to about 22% by weight formalin, based on the weight of the fabric. In one embodiment, for example wherein the fabric comprises cotton fibers, the fabric is treated with about 5% to about 8% formalin, based on the weight of the fabric. In another embodiment, for example wherein the fabric comprises rayon fibers, the fabric is treated with from about 12% to about 20% by weight formalin, based on the weight of the fabric. In yet another embodiment, for example wherein the nonelastic fibers in the fabric comprise a 50/50 rayon/polyester blend, the fabric is treated with from about 12% to about 20%, more specifically about 16%, by weight formalin, based on the weight of the fabric. While "formalin" refers to an aqueous solution comprising 37%, by weight, formaldehyde, as will be apparent to one of skill in the art, formaldehyde solutions comprising levels of formaldehyde other than 37%, by weight, may also be used. Using the above ranges of formalin, the fabric is treated with actual formaldehyde, as opposed to formalin, at a level of from about 0.5% to about 8%, specifically from about 1% to about 7%, based on the weight of the fabric. Thus, in one embodiment, for example wherein the fabric comprises cotton fibers, the fabric is treated with about 1% to about 3% formaldehyde, as opposed to formalin, based on the weight of the fabric. In another embodiment, for example wherein the fabric comprises rayon fibers, the fabric is treated with from about 5% to about 7% by weight formaldehyde, as opposed to formalin, based on the weight of the fabric. In yet another embodiment, wherein the nonelastic fibers in the fabric comprise a 50/50 rayon/polyester blend, the
fabric is treated with about 4% to about 7% by weight formaldehyde, as opposed to formalin, based on the weight of the fabric.

Suitable catalysts are those capable of catalyzing a cross-linking reaction between formaldehyde and a natural fiber, and specifically are catalysts capable of catalyzing the cross-linking of formaldehyde with a natural fiber comprising hydroxy groups, such as cellulosic fibers. Catalysts which may be used include mineral acids, organic acids, salts of strong acids, ammonium salts, alkylamine salts, metallic salts and combinations thereof. In one embodiment the catalyst is other than a mineral acid.

Suitable mineral acid catalysts include hydrochloric acid, sulfuric acid, nitric acid, phosphoric acid and boric acid. Suitable organic acids include oxalic acid, tartaric acid, citric acid, malic acid, glycolic acid, methoxyacetic acid, chloroacetic acid, lactic acid, 3-hydroxybutyric acid, methane sulfonic acid, ethane sulfonic acid, hydroxymethane sulfonic acid, benzene sulfonic acid, p-toluene sulfonic acid, cyclopentane tetracarboxylic acid, butane tetracarboxylic acid, tetrahydrofuran-tetracarboxylic acid, nitrilotriacetic acid, and ethylenediaminetetraacetic acid. Suitable salts of strong acids include sodium bisulfate, sodium dihydrogen phosphate and disodium hydrogen phosphate. Suitable ammonium salts include ammonium chloride, ammonium nitrate, ammonium sulfate, ammonium bisulfate, ammonium dihydrogen phosphate and diammonium hydrogen phosphate. Suitable alkanolamine salts include the hydrochloride, nitrate, sulfate, phosphate and sulfamate salts of 2-amino-2-methyl-1-propanol, tris (hydroxymethyl) aminomethane and 2-amino-2-ethyl-1-3-propanediol. Suitable metal salts include aluminum chlorohydroxide, aluminum chloride, aluminum nitrate, aluminum sulfate, magnesium chloride, magnesium nitrate, magnesium sulfate, zinc nitrate, zinc sulfate, and mixtures thereof.

In one embodiment of the invention, the catalyst is a halide or nitrate salt of zinc or magnesium, and preferably the catalyst is magnesium chloride. An organic acid, such as citric acid, may be used in combination with the halide or nitrate salt of zinc or magnesium. Generally the molar ratio of metal salt to organic acid is from about 5:1 to about 20:1. In one embodiment, the catalyst comprises magnesium chloride and citric acid, while in another embodiment the catalyst comprises magnesium chloride and aluminum chloride.
The fabric is typically treated with an amount of catalyst sufficient to catalyze cross-linking of the natural fibers by the formaldehyde to provide improved dimensional stability and/or improved durable press while maintaining stretch recovery properties. In one embodiment, the catalyst may be employed in an amount sufficient to provide a formaldehyde:catalyst weight ratio of from about 10:1 to about 1:10, and specifically from about 5:1 to about 1:5.

The formaldehyde treatment composition may comprise, by weight, up to about 12% of a catalyst solution, and specifically from about 1% to about 9% of a catalyst solution. Generally the catalyst solution comprises from about 20% to about 50%, by weight catalyst. In one embodiment, for example wherein the elastic fabric comprises cotton fibers, the treatment solution comprises from about 2 to about 4% by weight of a catalyst solution comprising about 30% by weight catalyst, and in another embodiment, for example wherein the elastic fabric comprises rayon fibers, the treatment solution comprises from about 6% to about 8% by weight of a catalyst solution comprising about 30% by weight catalyst. In yet a further embodiment, the catalyst solution comprises about 40%, by weight, magnesium chloride, for a final magnesium chloride level of up to about 5%, by weight of the treatment solution. Suitable catalyst solutions include FREECAT® LF (magnesium chloride and citric acid) and FREECAT® No. 9 (aluminum chloride and magnesium chloride), commercially available from B. F. Goodrich.

The formaldehyde treatment composition typically comprises a liquid carrier, preferably water, although, as noted above, the formalin used to prepare the treatment composition may comprise small amounts of organic solvents such as methanol or the like. In one embodiment, the treatment composition is free of any organic solvents other than that present in the formalin or the catalyst solution. In another embodiment, the carrier may comprise pentamethylocyclosiloxane.

According to exemplary embodiments of the present invention, a silicone elastomer or precursor thereof may be further included in the formaldehyde-containing treatment composition with which the fabric is treated. According to these embodiments, the formaldehyde treatment composition comprises formaldehyde, catalyst and silicone elastomer or a precursor thereof. The combination of a silicone elastomer or precursor thereof and the formaldehyde-containing treatment composition provides the fabric with
good strength and/or water absorbency, while also providing good durable press and/or shrinkage resistance properties. The good water absorbency is remarkable in that many conventional durable press and/or shrinkage resistance treatments render the treated fabrics hydrophobic. The good strength is evident in a reduction of the loss in tear and tensile strength that typically occurs during formaldehyde cross-linking of fibers.

Various silicone elastomers are known in the art and are suitable for use in the methods and fabrics of the invention. In one embodiment, the silicone elastomer is a polysiloxane. Similarly, the silicone elastomer precursor which forms an elastomer upon curing, typically by self curing, may be a polysiloxane. Elastomers are polymers which are capable of being stretched with relatively little applied force, and which return to the unstretched length when the force is released. Silicone elastomers have a backbone made of silicon and oxygen with organic substituents attached to silicon atoms, with a number n of repeating units of the general formula:

\[ \left[ \frac{\text{S}}{\text{R}} \frac{\text{R'}}{\text{R}} \right]_n \]

The groups R and R' are each independently selected from lower alkyls, preferably C1-C3 alkyls, phenyl, or lower alkyls or phenyls comprising a group reactive to cellulose, such as hydroxy groups, halogen atoms, for example, fluoride, or amino groups. Suitable elastomers include those disclosed in U. S. Patent No. 5,885,303, incorporated herein by reference.

A preferred silicone elastomer or precursor composition comprises up to about 60%, by weight, silicone solids. In one embodiment, the silicone elastomer or precursor composition comprises from about 20% to about 60%, specifically from about 30% to about 60%, by weight of silicone solids, while in another embodiment the silicone elastomer or precursor composition comprises from about 20% to about 30% by weight of silicone solids. Suitable silicone elastomer precursors include a dimethyl silicone emulsion containing from about 30% to about 60%, by weight, silicone solids, commercially available as SM2112 from General Electric. Another suitable commercially available elastomer precursor is Sedgesoft ELS from Sedgefield Specialties, containing from about 24% to about 26%, by weight, silicone solids.
When the silicone elastomer or precursor thereof is applied to the fabric with a liquid formaldehyde treatment composition, the liquid treatment composition may comprise up to about 4%, specifically from about 0.1% to about 2.5%, more specifically from about 0.2% to about 2%, by weight of the elastomer or precursor solids. In one embodiment, the treatment composition comprises from about 0.2% to about 2%, specifically from about 0.6% to 1.2%, by weight silicone solids, while in another embodiment, the composition comprises from about 0.2% to about 0.8% by weight silicone solids.

The formaldehyde treatment composition may be applied to the fabric in accordance with any of the conventional techniques known in the art. In one embodiment, a liquid treatment composition may be applied to the fabric by saturating the fabric in a trough and squeezing the saturated fabric through pressure rollers to achieve a uniform application (padding process). As used herein "wet pick-up" refers to the amount of treatment composition applied to and/or absorbed into the fabric based on the original weight of the fabric. "Original weight of the fabric" or simply "weight of the fabric" refers to the weight of the fabric prior to its contact with the treatment composition. For example, 50% pick-up means that the fabric picks up an amount of treatment solution equal to 50% of the fabric's original weight. In specific embodiments, the wet pick-up is at least 20%, specifically from about 50% to 100%, more specifically from about 65% to about 80%, by weight of the fabric.

Other application techniques which may be employed include kiss roll application, engraved roll application, printing, foam finishing, vacuum extraction, spray application or any process known in the art. Generally these techniques provide lower wet pick-up than the padding process. The concentration of the chemicals in the solution may be adjusted to provide the desired amount of chemicals on the original weight of the fabric (OWF).

In a preferred embodiment, the formaldehyde treatment composition is applied in an amount to insure a moisture content of more than 20% by weight, specifically more than 30% by weight, on the fabric before curing. Optionally, a wetting agent may be included in the treatment composition to facilitate obtaining the desired moisture content. Nonionic wetting agents are preferred.
Once the treatment composition has been applied to the fabric, the fabric is typically heated for a time and at a temperature sufficient for the cross-linking of the natural fibers with the formaldehyde. For example, the fabric may be heated at a temperature greater than about 250°F, specifically from about 250°F to about 375°F, in an oven for a period of from about 10 seconds to about 15 minutes, specifically from about 45 seconds to about 3 minutes, to react the formaldehyde with the natural fibers in the fabric and affect crosslinking of the formaldehyde and natural fibers to provide improved dimensional stability and maintained stretch recovery properties together with effects such as, durable press and/or shrinkage resistance. There is an inverse relationship between curing temperature and curing time, that is, the higher the temperature of curing, the shorter the dwell time in the oven; conversely, the lower the curing temperature, the longer the dwell time in the oven. Additionally, the inventors of the present invention have unexpectedly discovered that the treatment of the unique blend of synthetic elastic fibers and natural fibers of the present fabrics minimizes up stream processing normally incurred with relaxation, boil off and/or jamming procedures for elastic fabrics containing spandex/elastane fibers. As used herein, "relaxation", "boil off", and "jamming" procedures each refer generally to thermal processes which employ heat, moisture, and tension to maximize the physical contraction of an elastic fiber. By minimizing such processing steps, the amount of time required wherein the temperature is at or above about 120°F is reduced. Additionally, the jamming process may be incorporated into the same procedure for the crosslinking process. The single process flow procedure may then serve for multiple finishing operations i.e., jamming, crosslinking, formaldehyde removal, and heat setting. By consolidating these heat treating procedures, the life of the fabric may be increased. Without being bound by theory herein, the inventors therefore believe that the abovementioned desirable properties exhibited by the fabrics of the present invention are enhanced by the combination of both the chemical and mechanical and/or procedural aspects of the processes disclosed herein.

In another embodiment, the present invention comprises methods for improving dimensional stability and/or durable press while maintaining stretch recovery properties of fabric, wherein the silicone elastomer may be included in the treated fabric by means of a separate treatment step before or after the formaldehyde crosslinking treatment.
Additionally, if the silicone elastomer or precursor thereof is applied to the fabric subsequent to treatment with the formaldehyde crosslinking composition, the silicone elastomer precursor thereof may be applied prior to or subsequent to the processing step which is employed to affect curing of the formaldehyde with the natural fibers of the fabric, although in specific embodiments application prior to processing may be desirable. The applied silicone elastomer or precursor thereof may be dried, with self curing of the precursor being affected thereby.

The fabrics according to the invention exhibit good durable press properties and/or good shrink resistance. In one embodiment, it is preferred that the fabric exhibit good durable press, for example a DP (durable press) rating of at least about 3.0, specifically at least about 3.5, as measured according to AATCC Test Method 124-1996, after one aqueous washing, more specifically after five aqueous washings, and/or good dimensional stability, for example a dimensional change in length and width of less than about 5% each, specifically less than about 4.5% each, more specifically less than about 4.0% each, and in certain embodiments, less than about 3.0% each as measured according to AATCC Test Method 135-1995, after one machine washing, more specifically after five aqueous washings. Shrinkage resistance and/or dimensional change may also be measured according to AATCC Test Method 150-1995. In further embodiments, the fabrics exhibit good filling tensile and tear strengths, for example of at least about 25 pounds and at least about 24 ounces, respectively, as measured according to ASTM D-5035-95 for tensile strength, and ASTM D-2261-96 for tear strength.

The fabrics according to the invention also exhibit excellent smoothness appearance and appearance retention with usage over time. Without being limited by theory herein, the present inventors believe that the unique combination of properties for formulating the elastic fabrics according to the present invention can be used to produce fabrics with highly desirable feel and appearance properties, which have been otherwise unattainable by previously known methods. More particularly, it has been discovered that elastic fabrics comprising a blend of synthetic elastic fibers and natural fibers, can be used to produce garments that have excellent stretch/recovery properties while minimizing unwanted fabric growth according to ASTM Test Method D3107; have minimal dimensional change over multiple washing cycles according to AATCC Test
Method 135; have improved color appearance after multiple washings as rated by the AATCC Gray Scale for Color Change; resist wrinkling to minimize the need for ironing according to ASTM Test Method D2654; and dry in less time (i.e., about half the time of conventional fabrics) to minimize the degradation of elastic fibers therein according to ASTM Test Method D2654.

Furthermore, such fabrics avoid the cost and complexity typically associated with previous production methods, particularly during the preparation, dyeing and finishing steps which are utilized to control jamming and/or the shrinkage of the fabrics. These production benefits include, for instance, the elimination and/or reduction of heat setting, scouring and/or cool down processes typically found in previous fabric production techniques. Moreover, the processes of the present invention produce fabrics exhibiting reduced relaxation time, ply reduction and sectional slitting typically required by most fabrics during garment manufacturing, particularly as the sizing qualities of the fabrics are improved through dimensional change reductions of cut pattern pieces during garment production. Additionally, the fabrics have various cutting room advantages such as, for instance, reduced conditioning time, increased layering prior to cutting, improved tolerance for fabric sizing, the elimination of cutting sections for fabric relaxation and the ability to utilize less fabric than traditionally needed during production processes to make the garments. Moreover, and without being limited by theory herein, the inventors believe that fabrics treated via the processes of the present invention will have improved fabric handling characteristics during storage, as such fabrics exhibit reduced and/or eliminated bow and skew properties.

In a further embodiment, the fabrics according to the invention exhibit good hand or softness, in the absence of conventional softeners such as silicone or polyethylene softeners. Typically, the fabrics will exhibit a low coefficient of friction and/or a high flexibility/Instron softness.

In processes in accordance with the present invention, unreacted formaldehyde remaining on the fabric is removed during subsequent processing of the fabric. Generally, the final substrate will comprise less than about 300 ppm formaldehyde, specifically less than about 200 ppm formaldehyde, more specifically less than about 100
ppm formaldehyde, and even more specifically less than about 50 ppm formaldehyde, as measured according to AATCC Test Method 112-1993.

Some polysiloxanes, generally referred to as silicone oils, have a liquid form, are not elastomeric and do not self-crosslink. Silicone oils include, for example, non-reactive linear polydimethyl siloxanes, that is, siloxanes which are not capable of further reaction with other silicones and are not capable of a self curing reaction. Silicone oils have a tendency to produce non-removable spots on fabrics. In contrast, the silicone elastomers used in the present invention generally do not produce such spots. Although the fabrics or treatment compositions may comprise silicone oil, in one embodiment, the fabrics and treatment compositions are substantially free of, and specifically are free of, silicone oil. As used herein, substantially free of silicone oils means the treatment compositions and fabrics comprise less than 1%, by weight, silicone oil.

Thermosetting resins used to impart durable press properties to fabrics are generally aminoplast resins which are the products of the reaction of formaldehyde with compounds such as urea, thiourea, ethylene urea, dihydroxyethylene urea and melamines. As used herein “aminoplast resins” is intended to include N-methylolamide cross-linking agents such as dimethylol dihydroxyethylene urea, dimethylol urea, dimethylolethylene urea, dimethylol propylene urea, dimethylol methyl carbamate, dimethylol n-propylcarbamate, dimethylol isopropylcarbamate trimethylolated melamine, and tris(methoxymethyl) melamine. Specifically, the fabrics, methods and formaldehyde treatment compositions of the invention are substantially free of, and more specifically are free of, aminoplast resins and N-methylol cross-linking agents. As used herein, “substantially free” of aminoplast resins and N-methylol cross-linking agents is intended to mean the fabrics and treatment solutions comprise less than about 0.5%, by weight, aminoplast resin or methylol cross-linking agent.

Prior to treatment with the formaldehyde composition and silicone elastomer or precursor thereof, the fabric may optionally be prepared using any fiber, yarn, or textile pre-treatment preparation techniques known in the art. Suitable preparation techniques include brushing, singeing, desizing, scouring, mercerizing, and bleaching. For example, fabric may be treated by brushing which refers to the use of mechanical means for raising surface fibers which will be removed during singeing. The fabric may be then be singed
using a flame to burn away fibers and fuzz protruding from the fabric surface. Textiles may be desized, which refers to the removal of sizing chemicals such as starch and/or polyvinyl alcohol, that are put on yarns prior to weaving to protect individual yarns. The fabrics may be scoured, which refers to the process of removing natural impurities such as oils, fats and waxes and synthetic impurities such as mill grease from fabrics. Mercerization refers to the application of high concentrations of sodium hydroxide to a fabric to alter the morphology of fibers, particularly cotton fibers. Fabrics may be mercerized to improve fabric stability and luster. Finally, bleaching refers to the process of destroying any natural color bodies within the natural fiber. A typical bleaching agent is hydrogen peroxide.

The various preparation techniques are optional and dependent upon the desired final product. For example, when the final fabric is to be dyed a dark color, there may be no need to bleach the substrate. Similarly, there may be no need to desize a knit which was prepared without using any sizing agents, and no need to separately scour knits and woven textiles as the scouring may be done during bleaching.

The following examples are set forth to demonstrate the methods of the present invention and the improved dimensional stability and/or durable press properties together with maintained stretch recovery properties which are obtained in elastic fabrics by the methods of the present invention. Throughout the examples and the present specification, parts and percentages are by weight unless otherwise specified. The following examples are illustrative only and are not intended to limit the scope of the methods and fabrics of the invention as defined by the claims.

**Example 1**

In this example, elastic fabric samples are provided with a formaldehyde crosslinking treatment in accordance with the invention. According to this example, an elastic fabric comprising 97% rayon and 3% spandex is treated with from about 15% to about 22% by weight of formalin (37% formaldehyde), from about 3% to about 6% of a catalyst solution, and from about 0.1% to about 1.5% of silicone elastomer solids.

**Example 2**

In this example, elastic fabric samples are provided with a formaldehyde crosslinking treatment in accordance with the invention. According to this example, an
elastic fabric comprising 65% cotton, 32% rayon and 3% spandex, is treated with from about 15% to about 18% by weight of formalin (37% formaldehyde), about 3% of a catalyst solution, and about 1% silicone elastomer solids.

The examples and specific embodiments set forth herein are for illustrative purposes only and are not intended to limit the scope of the methods and fabrics of the invention. Additional methods and fabrics within the scope of the claimed invention will be apparent to one of ordinary skill in the art in view of the teachings set forth herein.
What is claimed is:

1. A method for providing elastic fabric comprising synthetic elastic fibers and natural fibers with improved dimensional stability while maintaining stretch recovery properties of the fabric, characterized by comprising treating elastic fabric comprising synthetic elastic fibers and natural fibers with a treatment composition comprising formaldehyde and a catalyst for crosslinking the formaldehyde with the natural fibers in the fabric, and processing the treated fabric to effect crosslinking of the formaldehyde and to maintain stretch performance properties.

2. A method for providing elastic fabric comprising synthetic elastic fibers and natural fibers with improved durable press while maintaining stretch recovery properties of the fabric, characterized by comprising treating elastic fabric comprising synthetic elastic fibers and natural fibers with a treatment composition comprising formaldehyde and a catalyst for crosslinking the formaldehyde with the natural fibers in the fabric, and processing the treated fabric to effect crosslinking of the formaldehyde and to maintain stretch performance properties.

3. The method of any of Claims 1-2, wherein the treatment composition further comprises a silicone elastomer or a precursor thereof.

4. The method of any of Claims 1-3, wherein the fabric comprises from about 0.5% to about 20% by weight of the synthetic elastic fibers.

5. The method of any of Claims 1-4, wherein the synthetic elastic fibers comprise at least about 85% of a segmented polyurethane.

6. The method of any of Claims 1-5, wherein the fabric comprises at least about 20% by weight of the natural fibers.
7. The method of any of Claims 1-6, wherein the treatment composition is free of aminoplast resin.

8. A fabric characterized by comprising synthetic elastic fibers and natural fibers and exhibiting a durable press value of at least about 3.0 after the fabric has been aqueous laundered one time.

9. A fabric of Claim 8, wherein the fabric exhibits a fabric growth of not greater than about 5% after the fabric has been stretched at least about 80%.

10. A fabric characterized by comprising synthetic elastic fibers and natural fibers and exhibiting a length dimensional change and a width dimensional change of less than about 5% each after the fabric has been aqueous laundered one time.