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METHOD FOR PREPARING NONWOVEN SUBSTRATES

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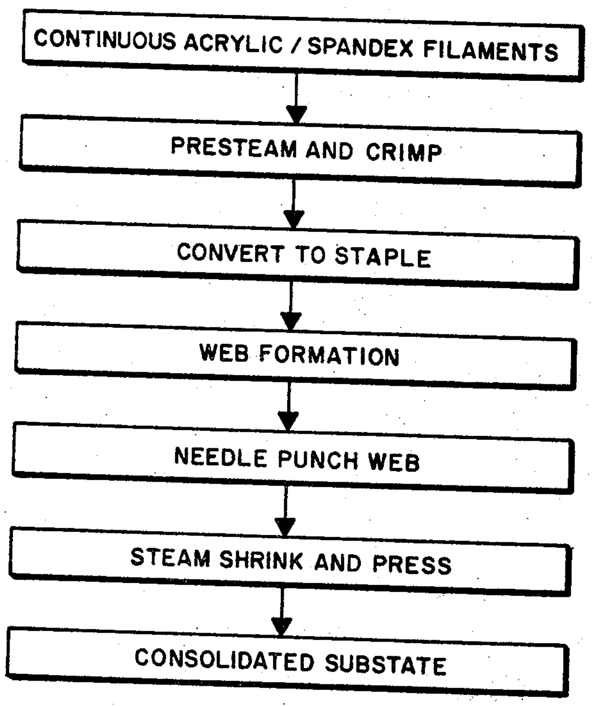

FIG. 1.

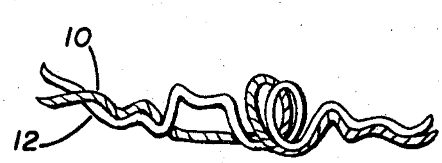

FIG. 2.

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METHOD FOR PREPARING NONWOVEN SUBSTRATES

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ABSTRACT OF THE DISCLOSURE

A method for making nonwoven fabrics prepared from heat retractable inelastic/elastic bicomponent fibers composed of a heat-retractable elastic component which shrinks under heated conditions to cause partial separation thereof from the inelastic component whereby improved elastic properties are imparted to the shrunken fabric. Another important aspect of the invention resides in the ability to advantageously card and needle punch the bicomponent fibers as hard fibers which obviates the necessity of physically blending elastic fibers and inelastic fibers when it is desirable to provide a non-woven fabric having an elastic fiber element.

It is conventional in the prior art to blend two or more types of staple fibers of which one is an elastic fiber to obtain a fabric having enhanced recovery properties. The blending has been accomplished by physically blending the staple fibers using conventional textile machinery such as Rando-Webbers, hopper-fed woolen blenders, and cotton cards. In each of the blending operations an additional step is required and a homogeneous intimate mixture is difficult to achieve. However, it has been found that fine denier spandex fibers cannot be blended by the conventional blending methods.

It is an object of the present invention to provide a method for preparing nonwoven substrates having improved elastic recovery properties from predominately inelastic bicomponent staple fibers.

Another object of the present invention is to provide a method for making nonwoven fabrics having improved elongation and flexibility.

Another object of the present invention is to provide a method for making nonwoven fabrics having improved crease recovery and wrinkle resistance.

A further object of the present invention is to provide a method for making highly elastic nonwoven fabrics by in situ development of the reserved elastic properties of an entangled web of fibers having handling properties similar to hard fibers.

Other objects and advantages of the invention will become apparent from a reading of the following detailed specification.

In accordance with the present invention inelastic/elastic bicomponent continuous filaments may be exposed to a small amount of steam to partially relax and crimp the fiber prior to conversion to staple which is formed into a web that is needle punched and steamed to consolidate the fibers into a dense, highly elastic nonwoven fabric. The shrunken web may be further consolidated by pressing or embossing.

Methods for producing bicomponent fibers highly suitable for preparing the product of this invention are fully described in copending application Ser. No. 369,259, filed May 21, 1964. Preferably, the elastic component of the bicomponent fibers is between about 15 and 25 percent by weight of the total fibers. The bicomponent fibers as contemplated by this invention may be blended with up to 50 percent of other fibers which include all of the man-made synthetic and natural fibers.

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The webs may be of single layer constructions or a multilayered composite consisting of several layers of fibers of which some have different shrinkage characteristics. Also it may be advantageous to lay the fibers predominately in one direction to build into the fabric superior elastic recovery in that direction. In either event the elastic content should be at least 10 percent of the total content to produce a lively web having elastic properties not generally achieved for nonwoven products.

The process steps of the invention are illustrated in FIGURE 1 of the accompanying drawing. The fibers preferred are bicomponent acrylic/spandex filaments as shown in FIGURE 2 which are spun in accordance with the procedures set forth in copending application Ser. No. 369,259. The filament is comprised of an elastic component **10** and an inelastic component **12** arranged in a side-by-side relationship with the components fused together. They are essentially straight and assume the nonelastic characteristics of inelastic filaments. The inelastic nature of these filaments facilitates improved handling such as carding and needle punching in addition to the achievement of a homogeneous mixture. In the first step the filaments may advantageously be exposed to a small amount of steam to cause a slight amount of prebulking to condition the filaments for mechanical crimping to facilitate improved processing characteristics. The crimped filaments are reduced into staple fibers which have handling properties similar to hard fibers. A web is formed from the staple fibers by conventional carding or web formation techniques and condensed by conventional needle punching or stitch-through processes. Needling of the web is accomplished with very little spreading because of the interfiber cohesiveness imparted to the fibers by the mechanical crimp in conjunction with the presteaming step. The interfiber cohesiveness of the fibers in the needled web is noticeably higher than in conventional nonwovens because of the presence of the elastic component. While staple fibers are preferred for use in this invention, continuous filaments also may be employed. Methods for preparing webs from continuous filaments are known in the art.

The needled web is placed in a hot water bath at approximately 95° C. for several minutes whereby the elastic portion **12** tends to retract because of the stretched condition which is imposed by drawing of the bicomponent filament thereby causing separation of the fiber components at random intervals which causes the inelastic portion to coil and also causing the unseparated fiber portions to crimp as illustrated in FIGURE 2. Retraction of the elastic component in conjunction with the crimping and shrinking of the unseparated portion causes an area reduction of more than 50 percent. The retracted web is unexpectedly dense and possesses a lively hand. The density of the web is increased by pressing to a desired thickness.

The product of this invention has several unique aspects which result primarily from the performance of the elastic/inelastic bicomponent fibers employed in the web. One notable property exhibited by this product is the instant recovery from a high elongation which is imposed by the residual elasticity of the separated elastic fiber portions. Heretofore, nonwovens have been characterized by good recovery at low elongation but very poor recovery at high elongation. This adverse condition is accounted for by the fact that fiber crimp in conventional nonwoven products is responsible for good recovery at low elongation, but does not produce good recovery at elongations which exceed the stretch permitted by fiber crimps. Nonwovens described herein have an immediate recovery greater than 70 percent after undergoing over a 25 percent strain. Therefore, the novel product of this invention possesses a liveliness that is lacking in the conventional nonwovens.

The following examples illustrate several specific embodiments of the invention wherein all parts are by weight unless otherwise indicated.

EXAMPLE I

Approximately 27 grams of 1.5 denier acrylic/spandex (75/25) staple fiber mixed with 3 grams of 2.0 denier acrylic staple fiber was fed through a miniature Shirley card and collected on the revolving drum to form a batt. The acrylic/spandex bicomponent fibers were prepared from the compositions and techniques set forth in Example VI of copending application Ser. No. 369,259. The all acrylic fibers were wet spun from a solution of a polymer of 94 percent acrylonitrile and 6 percent vinyl acetate. The staple fibers were 1.5 inches in length. The acrylic/spandex staple was cut from a tow which had been exposed to a small amount of steam to partially relax and crimp the fiber before passing through a mechanical crimping device.

The prerelaxation of the bicomponent filaments by brief exposure to steam leads to a bulkier, more highly crimped staple which gives more uniform and coherent card webs with reduced spreading during needling. Furthermore, when mechanical crimping is preceded by the steam treatment, the fiber is less severely damaged as evidenced by higher tensile properties shown in the following table:

TENSILE PROPERTIES

	Tenacity, g./d.	Elong., percent
Uncrimped filament, as-spun:		
25% spandex	3.27	19.4
15% spandex	3.34	17.4
Mechanically crimped dry:		
25% spandex	2.26	19.0
15% spandex	2.38	12.4
Mechanically crimped after brief exposure to steam:		
25% spandex	2.75	21.0
15% spandex	3.33	17.9

The batt was needle-punched once on each side to a total of 3000 punches/in.^{2}. At this stage the needled web had the following properties:

Thickness (mil)	60.0
Weight (oz./yd.^{2})	2.6
Density (g./cc.)	0.057
Tenacity (lb./in./oz./yd.^{2})	0.45

The needled web was placed in a hot water bath at 95° C. for several minutes resulting a 79 percent loss in surface area. The retracted web was oven dried at 100° C. and then pressed between heated plates (100° C.) for 5 minutes under a pressure of 5 tons employing two 1/16 inch aluminum spacers between the plates. A uniform, dense, and lively nonwoven fabric with the following physical properties was obtained:

Thickness (mil)	83.0
Weight (oz./yd.^{2})	12.2
Density (g./cc.)	0.20
Tensile strength (lb./in.):	
Machine	17.88
Transverse	11.67
Tenacity (lb./in./oz./yd.^{2}):	
Machine	1.50
Transverse	0.98
5% modulus (lb./in./oz./yd.^{2}):	
Machine	0.285
Transverse	0.223
Elongation (percent):	
Machine	256
Transverse	252
Bending length (in.):	
Machine	1.1
Transverse	1.2
Performance coefficient:	
Machine	16.2
Transverse	9.7

The retracted, needle-punched fabric had the following elastic recovery properties:

Strain, percent	Immediate recovery, percent		Recovery after 3 min., percent	
	Machine	Transverse	Machine	Transverse
5	88.7	81.8	100	100
10	91.2	89.5	98.6	99.4
20	83.7	81.0	94.0	90.6
30	77.9	76.2	89.8	80.1

The thickness and density of the retracted web was regulated by the degree of pressing used.

EXAMPLE II

A batt composed of 100 percent acrylic/spandex staple (25 percent spandex, 3.0 d.p.f., 1.5 inch) was prepared by the techniques employed in Example I. The unretracted needle web had the following properties:

Thickness (mil)	68.0
Weight (oz./yd.^{2})	2.6
Density (g./cc.)	0.05
Tenacity (lb./in./oz./yd.^{2}), machine	0.46
Elongation, (percent), machine	62.0
Bending length (in.), machine	0.94
Performance coefficient, machine	1.28

EXAMPLE III

A needle-punched, nonwoven fabric containing 3000 punches/in.^{2} was prepared according to Example I except that the fiber used was a bicomponent composed of 15 percent spandex and 85 percent acrylic (1.2 d.p.f., 1.5 inch staple length). The web was then retracted in hot (95° C.) water to a 75 percent loss of planar area. After drying and pressing the web had the following properties:

Thickness (mil)	92
Weight (oz./yd.)	13.7
Density (g./cc.)	0.185
Tensile strength (lb./in.):	
Machine	33.8
Transverse	16.1
Tenacity (lb./in./oz./yd.^{2}):	
Machine	2.47
Transverse	1.20
5 percent modulus (lb./in./oz./yd.^{2}):	
Machine	0.335
Transverse	0.429
Elongation (percent):	
Machine	281
Transverse	204
Bending length (in):	
Machine	1.25
Transverse	1.28
Performance coefficient:	
Machine	27.0
Transverse	12.6

The retracted, needle-punched fabric had the following elastic recovery properties:

Strain, percent	Immediate recovery, percent		Recovery after 3 min., percent	
	Machine	Transverse	Machine	Transverse
5	95.6	94.4	100	100
10	84.8	81.6	100	100
20	81.6	77.3	92.7	89.0
30	78.0	71.8	90.3	77.3

The above example shows that a web of 100 percent acrylic/spandex bicomponent fibers containing only 15 percent spandex is suitable for preparing webs in accordance with the invention.

EXAMPLE IV

This example demonstrates that a web composed of an all-acrylic heat retractable conjugate fiber blended with a minor proportion of monofilament acrylic fibers does not possess the elastic properties exhibited by the web prepared in accordance with this invention.

An all-acrylic fiber was compositely spun (pipe-in-pipe, single ring of holes, i.e., true conjugate) from polymer A (94 percent acrylonitrile, 6 percent vinyl acetate) and polymer B (92 percent acrylonitrile, 8 percent vinyl acetate). A blend of staple of this conjugate fiber (80 percent) and acrylic monofilament staple (20 percent) spun from a copolymer of 94 percent acrylonitrile and 6 percent vinyl acetate was processed into carded web, needle-punched, and retracted according to the procedure of Example I. A loss of planar area of 55.8 percent was obtained.

After drying and processing, the web weighed 8.1 oz./yd.^{2}, had a density of 0.116 g./cc., and a thickness of 93 mil. The web had the following elastic properties:

Strain, percent	Immediate recovery, percent		Recovery after 3 min., percent	
	Machine	Transverse	Machine	Transverse
5	95.8	93.6	100	100
10	82.3	89.9	94.7	100
20	57.2	77.5	72.8	87.0
30	40.1	64.2	52.8	75.5

A comparison of the elastic recovery data of Examples I and III with IV indicates that the elastic-containing webs of this invention are far superior to acrylic conjugate webs especially at higher strain levels. The good recovery properties of the acrylic conjugate web at the lower strain levels may be attributed to recovery from merely straightening out the crimp developed upon web retraction.

Fibers highly preferred for the preparation of the improved webs disclosed herein are acrylic/spandex bicomponent fibers consisting of between 15 and 25 percent spandex. These fibers have an exceptionally high retractive force when subjected to a heated environment. The retractive forces are illustrated in the table below. A 10-inch length of 5,000 denier tow was exposed to live steam at 95° C. for 5 minutes with the appropriate load imposed on the fibers. Afterwards the retracted tow length was measured to determine the percent shrinkage under a predetermined load.

The elastic content in the webs described herein imparts to the non-woven fabric several important properties. The fabric possesses a high degree of flexibility as evidenced from the bending length and low modulus which are attained by virtue of the unique combination of crimp and low modulus of the elastic component. Also, the potential heat setting characteristics of the webs permits improvements in pattern embossing and heat setting to a desired thickness. The product also offers the advantages that the fabric may be partially shrunk while in a hot press to improve uniformity thereof, or heated while the planar area of the fabric is held constant to improve web consolidation mainly in the thickness because of the high shrinkage and crimp forces of the fibers.

The term "performance coefficient" as used herein describes the combined properties of strength and drapability. It is the ratio of the breaking strength in pounds per inch of width of web to its bending length in inches. Bending length is determined according to ASTM Test D1388–55T. Briefly it is one-half the length of unsupported fabric necessary to bend under its own weight from the horizontal plane to contact a declining angle of 41.5° of slope from the point of departure to contact. Thus, the more drapable the fabric, the shorter the bending length. Since both high strength and drapability contribute to a high value, a high performance ratio is a desirable characteristic in a nonwoven fabric. The stress-strain measurements were carried out at a 5 inch gauge length, 1 inch sample width and at a rate of elongation of 100 percent per minute. The 5 percent modulus is calculated as the ratio of the fabric stress and lbs./in./oz./yd.^{2} to the fabric strain at an elongation of 5 percent. Rupture stress and elongation are taken at the point where the load supported by the fabric reach a maximum value. Elastic recovery measurements may be made at a 2 inch gauge length. The sample is extended at 10 percent per minute to a given elongation. The moving jaw of the tensile tester is then immediately reversed and returned to the starting point. The percentage of the return cycle required to reduce the fabric stress to zero is taken as the immediate elastic recovery. After 3 minutes the specimen is again extended, this time to a greater elongation. Permanent set is given by the displacement of the second stress-strain curve relative to the first. The difference between this amount and the original extension is a measure of the total recovery after 3 minutes. It also is reported as a percentage of the original extension. This process is continued for several elongations whereby the continued

HEAT SHRINKAGE AGAINST RESTRAINING LOADS

Load, g.p.d. (10^{-4})	Shrinkage, percent				
	25% Spandex			20% Spandex, 1.3 d.p.f.	15% Spandex, 1.3 d.p.f.
	1.3 d.p.f.	2.1 d.p.f.	3.0 d.p.f.		
0	82	80	80	82	79
3	73	61	62	71	68
6	68	54	55	66	62
12	63	44	47	60	49
18	59	38	40	54	33
24	56	32	35	47	25
30	52	27	30	38	21

While the invention has been illustrated primarily with the employment of acrylic/spandex bicomponent fibers, it is noted that bicomponent fibers which can be cospun in accordance with the principles disclosed in copending application Ser. No. 369,259, including other inelastic and elastomeric compositions, may be utilized. Also, useful fibers contemplated for preparing the product of this invention are the conjugates which are comprised of an inelastic fiber-forming composition cospun with a mixed polymer blend of inelastic and elastic fiber-forming compositions. It has been experienced however that the elastic content must be above 10 percent of the total content to obtain a web which exhibits a lively hand.

displacement of the stress-strain curve allows calculation of the elastic recovery corresponding to each preceding elongation. In practice, on successive cycles the sample is extended 5, 10, 20 and 30 percent.

We claim:

1. A method for making heat retracted nonwoven fabrics from bicomponent fibers having elastic/inelastic portions capable of partial separation and retraction when heated comprising the steps of forming a nonwoven web from said fibers, needle punching the web to increase fiber entanglement, and partially separating lengths of the elastic portion from the inelastic portion by contacting said web with heat to cause a retraction of the elastic

portion whereby a dense, highly elastic nonwoven fabric is produced.

2. The method of claim 1 in which at least 10 percent weight of the web is comprised of elastic fibers.

3. The method of claim 1 in which the fibers are presteamed prior to needle punching to partially bulk said fibers and to improve handling properties.

4. The method of claim 1 in which the web is retracted in a hot-water bath at approximately 95° C.

5. The method of claim 1 in which the surface area of the web is reduced greater than 50 percent from its original area.

6. The method of claim 1 in which the fibers by weight are comprised of 10 to 30 percent spandex and 70 to 90 percent acrylonitrile based copolymers.

7. The method of claim 1 in which the fibers are continuous.

8. The method of claim 3 in which the fibers are reduced to staple subsequent to presteaming.

9. The method of claim 1 in which the fibers are preferentially arranged in the construction of the web to impart superior elastic recovery in a preferred direction.

10. The method of claim 1 in which the fabric is heat set.

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