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FLEXIBLE NON-WOVEN SHEET MATERIAL AND METHOD OF MAKING THE SAME

Stuart P. Suskind and Roy D. Goodwin, Raleigh, N.C., assignors to Monsanto Company, St. Louis, Mo., a corporation of Delaware

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This invention relates to a flexible non-woven sheet material. More particularly, this invention relates to a non-woven sheet material having uniform density and improved dimensional stability which make it a useful substrate for preparing synthetic leather products. Also, the invention relates to a method for improving the web-forming properties of the staple fibers employed to produce a heat-retracted, non-woven sheet material.

Loosely matted synthetic fibers have been compacted by several mechanical processes in recent years to prepare non-woven sheet materials. These non-woven fabric structures derive their density and strength from the coherence obtained from interfiber entanglement. Therefore, the fibers must be interlaced with respect to each other in order to achieve the interfiber cohesion necessary to provide the strength required for most non-woven products. The interfiber entanglement is generally accomplished by penetrating the loosely carded staple fibers with a multiplicity of needles provided with hooked points or barbs. To obtain optimum carding and needling of the fibers, a certain amount of fiber crimp is essential. However, in the preparation of fibrous webs from self-crimping or heat shrinkable fibers for applications where needle marks are objectionable, it is desirable to delay complete development of the crimp until after the needling operation. The subsequent crimp will further consolidate the web and diminish the needle-punch marks.

Although the use of heat shrinkable fibers to prepare needle-punched, retracted non-woven webs is well known, several problems are encountered in the web formation and needling processes with fibers of this type. Because of the absence or low degree of fiber crimp possessed by these fibers prior to development of the latent crimp, thin batts prepared from heat-shrinkable fibers are often weak and poor in uniformity and cohesion. This result is compounded by the spreading of the uncrimped fibers during the needle-punching operation and the accompanying lack of uniform fiber entanglement.

Several attempts have been made in the past to improve the carding and needling characteristics of uncrimped staple fibers. One approach toward solving this problem has been to employ a special-type needle to reduce the fiber spreading. Another method has been to admix or blend crimped fibers with the uncrimped fibers to reduce their propensity to spread during needling. Another method has been to employ woven supporting scrims which are either incorporated permanently or removed after needling also is well known while these prior methods have somewhat improved the web cohesion and needling behavior of uncrimped fibers, they have not completely solved the problem. Therefore, it would be highly desirable to provide a simple and economical method for

producing an improved non-woven fabric structure from self-crimping fibers. Self-crimping fibers are those fibers having the ability to retract in length principally through curling or coiling when heated or chemically treated to impose a crimped condition.

With the foregoing in mind, it is an object of the present invention to provide a method for producing a thin non-woven fabric structure which has uniform density and improved strength from self-crimping fibers having little or no crimp.

Another object of the present invention is to provide a method for improving the needling characteristics of webs formed from loosely matted staple fibers which have little or no crimp.

A further object of the present invention is to provide a method for stabilizing the spreading propensity of synthetic fibers having a low degree of interfiber coherence while undergoing needle punching in a loosely matted web.

Yet another object of the present invention is to provide a flexible non-woven fabric structure having uniform density and excellent drape.

Still another object of the present invention is to provide a flexible non-woven fabric structure formed from loosely matted synthetic staple fibers which are stabilized dimensionally during needle punching without adversely affecting the shrinkage properties of said fibers or the bending length of said fabric structure.

Other objects and advantages of the invention will be apparent from the description to follow.

The above objects have been accomplished in accordance with the present invention which is a non-woven fabric structure comprised of a microfibrous web sandwiched between layers of coarser fibers which are interlaced in a cohering relationship with respect to each other through the microfibrous web by needle punching to entangle the coarser fibers and microfibers. The microfibers are less than 1 denier, and preferably less than 0.5 denier and the coarse fibers are greater than 1 denier, preferably 1.5 denier and above. In the production of non-woven fabric structures for use as substrates in the manufacture of poromeric materials such as synthetic leather, it has been discovered that a very dense web is essential in obtaining a suitable product. It is well known that dense webs are prepared from heat-shrinkable fibers which are formed into coherent batts by a needle-punching or similar process and then subjecting the batt to sufficient heat to shrink the fiber thereby substantially increasing the density of the web. Since the fibers preferably are not retracted until after the needle-punching operation, they possess only a slight amount of interfiber coherence. As stated earlier, the needling or similar fiber entanglement process causes the substantially straight fibers to separate and spread to the extent that uniform density of the web is difficult to be controlled.

According to the present invention the spreading of the fibers during the fiber entanglement step is controlled by the microfiber web which does not spread substantially because of the high degree of interfiber entanglement and accompanying frictional forces possessed by the microfibers. Microfiber webs can be prepared in a number of ways by conventional processes such as carding, deposition from an air stream or by paper-making techniques. Preferably, the microfiber webs are made by the processes disclosed in copending application Ser. No. 464,411 now Patent No. 3,317,954, and Ser. No. 464,477, filed June 16, 1965, wherein the microfibers are collected in continuous webs on a foraminous belt. The webs formed by these processes have excellent dimensional stability and are extremely flexible, which are two essential properties required of leather-like products.

Heretofore, woven fabrics or bonded non-woven fabrics have been employed in some instances to stabilize carded staple fibers during the needle-punching prouess. Because of the high degree of flexibility which must be maintained when manufacturing leather-like products, the known reinforcement scrims have been found to be unsatisfactory. On the other hand microfibrous webs provide the desired amount of dimensional stability to prevent the outer layers of coarser fibers from spreading and also add substantially to the density of the fabric structure without affecting adversely the flexibility or drape properties of the final product.

The outer layers of the product of this invention are prepared from any type of fibers having the capability to shrink into a consolidated web after the fibers have been compacted by a preferred fiber entanglement process. For example, the fibers may be an acrylic/elastomeric composite of the type disclosed in copending application Ser. No. 369,359 filed May 21, 1964; texturized unrelaxed nylon, polyester or acrylic fibers; high shrinkage acrylics, modacrylics, polyester, polyolefins or polyamides; bicomponent acrylic fibers; unrelaxed polyvinylchloride fibers; nylon conjugate fibers; or, blends of the above heat retractable fibers. In addition, minor amounts of cardable natural fibers may be employed as blends with the above synthetic fibers. The acrylic/elastomeric composite fiber is highly preferable because of its ability to shrink and consolidate the fibers into a dense, flexible web having a suitable amount of elasticity.

The relative amounts of coarse fibers and microdenier fibers may be varied considerably depending upon the dimensional stability desired to facilitate compacting of the coarse fibers prior to shrinkage of the compacted fibers. Obviously, some fibers have a greater propensity to spread than others and therefore are more difficult to control. It has been found that for most heat-retractable fibers a microfiber web comprising from 5 to 20% weight of the composite structure provide adequate strength to insure that uniform density is maintained. The microfibers being the minority constituent are disposed near the center with respect to the broad surfaces of the composite structure to prevent them from emerging to the surface and imposing their influence on the surface characteristics of the finished sheet material.

The product of this invention may vary in thickness from a very thin material of about 25 mils to about 100 mils, but preferably from about 50 to 70 mils after the fibers have been compacted and shrunk. The layered composite web, which has been compacted preferably by a needling process wherein the needles penetrate the three layers to reorient part of the fibers, should have the capability of shrinking at least 20 percent in planar area, and preferably more than 50 percent. Therefore, it is highly desirable that the web of fibers be consolidated to a uniform density prior to heat-retraction of the uncrimped fibers and that the reinforcing scrim which facilitates better web consolidation is comprised of a substrate that does not restrict, appreciably, the shrinkage of the heat-retractable web in order to produce a flexible sheet material having uniform density. Shrinkage of the web may be accomplished in hot water, steam or dry heat. After the web has been shrunk the proper amount, it may then be impregnated with an aqueous or solvent based synthetic elastomer and dried by a suitable technique, if desired, to produce a synthetic suede leather having excellent properties. The impregnated web may be buffed and brushed to raise fiber ends at the surface and to improve the bond and surface appearance. Optionally the impregnated web may be finished by dyeing or overlapping soil repellents and the like.

The product of this invention is an excellent substrate material for a finished synthetic leather product. The finishing or coating process may consist of applying a light-weight woven or non-woven scrim to add dimensional stability and strength; coating with a polymeric material; and surface coating this with a thin layer of a polymer to enhance abrasion resistance, durability and light stability.

The following examples illustrate the improvement achieved from the employment of a microfiber web in the preparation of needle punched webs of heat-shrinkable fibers.

Example I

A carded batt weighing 4.23 oz./yd.^{2} was prepared from 2.6 denier per filament, 1.5 inch polyester-polycarbonate conjugate staple fibers capable of developing a crimp on relaxation with heat. One-half of the fiber cross-section was 100 percent polyethylene terephthalate and the other half was a blend of 94 percent polyethylene terephthalate blended in the melt with 6 percent polycarbonate. The batt was needle punched once on each side for a total of 3,000 punches per square inch on a conventional needle loom. The needle-punched web had a density of 0.068 gm./cc. The web was then placed in a hot water bath (95° C.) for several minutes to retract the fibers. The reduction in planar area of the web was 35 percent resulting in a web.

Example II

A needle-punched web as in Example I was repeated with a microdenier acrylic web weighing 1.0 oz./yd.^{2} placed between the two polyester-polycarbonate staple batts prior to needle punching. The needle-punching step in Example I was repeated with a noticeable reduction in web spreading and visible needle marks which were experienced in the web from the preceding example. The web was retracted in a hot water bath (95° C.) with an accompanying area loss of 30 percent.

The web had a density of 0.084 gm./cc. before being heat retracted and 0.141 gm./cc. afterwards. Thus, the presence of the microfiber web substantially increased the density of the web before and after heat retraction. Because of the reduced spreading during the needle-punching step, the web containing the microfiber web was denser and more uniformly consolidated. The retracted web had a bending length of 1.44 inches which indicates that the microfiber web does not adversely affect the drapeability thereof.

Examples III–IV

These webs were constructed in accordance with the procedures used in Examples I and II except a different combination of fibers as shown in the following table were employed.

The data in the table below illustrates the improved strength and dimensional stability achieved by employment of a microfiber web. The outstanding improvements imparted to the webs by the microfiber interlay was the achievement of improved strength and web cohesion without any appreciable loss in flexibility or drape.

DEAD LOAD EXTENSION [1]

Sample (1″ width)	Time (min.)	L_0, (inch)[2]	ΔL (inch)	$\frac{\Delta L \times 100}{L_0}$[3]	Bending length (inch)[4]
Polyester-polycarbonate needle-punched—Test direction:					
Machine	15	4	1.8	45.0	1.48
	15	5	2.05	41.0	
	5	4	1.75	43.8	
Transverse	15	5	6.85	137.0	
	5	5	6.85	137.0	
Polyester-polycarbonate acrylic microfiber (AMF) web sandwich—Test direction:					
Machine	15	4	1.1	27.5	1.52
	15	5	1.2	24.0	
	5	4	1.05	26.2	
Needle-punched—Test direction:					
Transverse	15	4	0.65	16.3	
	15	5	0.75	15.0	
	5	4	0.60	15.0	
Dynel staple needle-punched [5]—Test direction:					
Machine	5	5	0.9	18.0	1.78
	15	5	1.15	23.0	
Transverse	5	5	4.6	92.2	
	15	5	4.7	94.1	
Dynel-AMF-Dynel needle-punched [6]—Test direction:					
Machine	5	5	0.7	14.0	1.83
	15	5	0.7	14.0	
Transverse	5	5	1.0	20.0	
	15	5	1.1	22.0	
Acrylic conjugate (80%), acrylic copolymer (20%) needle-punched—Test direction:					
Machine	5	5	1.2	24.0	1.86
	15	5	1.3	26.0	
Transverse		Sample broke			
Acrylic conjugate (80%), acrylic copolymer (20%) with AMF needle-punched—Test direction:					
Machine	5	5	0.7	14.0	1.81
	15	5	0.8	16.0	
Acrylic conjugate (80%), acrylic copolymer (20%) with polyvinylchloride microfiber web—Test direction:					
Machine	5	5	0.45	9.0	
	15	5	0.50	10.0	
Needle-punched—Test direction:					
Transverse	5	5	1.2	24.0	
	15	5	1.35	27.0	

[1] A weight of 161 gms. was hung freely from a one inch width sample.
[2] Original length.
[3] Percent elongation.
[4] Bending length was measured in accordance with ASTM-D-1384-64.
[5] High shrinkage fiber comprised of a copolymer of acrylonitrile and vinyl chloride in approximately a 60/40 ratio.
[6] AMF, acrylic microdenier fiber.

A comparison of the data obtained from webs without the microfibers and similar webs reinforced with the microfibers in the above table indicates that the microfibers impart a substantial amount of strength to the web structures. Particular attention should be given to the fact that the bending length of the sheet material is not significantly increased by the microfibers.

What is claimed is:

1. A flexible non-woven sheet material having a uniform density which is comprised of two layers of unretracted synthetic staple fibers being entangled with respect to each other through a layer of microfibers disposed between said layers to form a composite structure.

2. The product of claim **1** in which the staple fibers are at least 1 denier per filament and the microfibers are less than 1 denier per filament.

3. The product of claim **2** in which the staple fibers are self-crimping when heated to effect at least a 20 percent area loss of said sheet material.

4. The product of claim **2** in which the microfibers possess a high degree of interfiber entanglement which improves the dimensional stability and density of the sheet material.

5. The product of claim **2** in which the staple fiber entanglement through the microfibers is accomplished by needle punching.

6. The product of claim **2** in which the microfibers comprise from about 5 to 15 percent by weight of the composite structure.

7. The product of claim **6** further characterized by impregnation in an elastomeric composition.

8. The product of claim **7** further characterized by a polymeric surface coating.

9. A method for improving the web-formation properties of self-crimping synthetic fibers which comprises:

(a) disposing a batt formed from the fine denier fibers having a high degree of interfilamentary cohesion between two layers of coarser synthetic fibers to form a composite structure, and

(b) needle punching the composite structure to effect an interlacing of the coarser fibers through the fine denier fibers in a cohering relationship with each other to provide a flexible web having uniform density and improved dimensional stability.

10. The method of claim **9** in which the needle-punched web is shrunk at least 20 percent to effect densification thereof by retractnig the coarser staple fibers in a heated environment.

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ROBERT F. BURNETT, Primary Examiner

R. L. MAY, Assistant Examiner

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