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UNWOVEN FABRIC

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My invention relates to an unwoven fabric having general utility in the arts, but characterized by properties rendering it of particular interest as a bandaging material, especially in orthopedia in which connection it will be particularly described.

A variety of bandaging materials are presently being used in orthopedics and allied arts as padding under rigid supports such as plaster casts, splints, and braces, and as padding under elastic bandages, elastic stockings and the like for the correction of circulatory disturbances such as phlebitis or varicosities. All these bandaging materials are inconvenient and cumbersome to apply, and many are further deficient in that, being of very low strength, they offer little or no support to the affected member, the dressing representing merely a built-up, bulky padding. Moreover, a dressing formed of the conventional materials is prone to develop pressure points under a cast due to wrinkling and bunching, does not conform overly well to the contour of the member because of its lack of elasticity, and in the case especially of the constructions comprising crepe paper, cellucotton or sheet wadding, tends to disintegrate when wet.

The fabric herein is not subject to any of the indicated disadvantages. It provides excellent support, being both elastic and conformable; it is nonconstricting, even with pronounced swelling, and is virtually incapable of bunching or wrinkling. Its wet strength is substantial. It is highly absorbent and retentive of suppurative discharges, perspiration, blood, etc., and thus promotes the health of the covered body tissues. Due to its high permeability, it permits unhampered circulation of air, which avoids stagnation by facilitating evaporation of absorbed fluids. Despite its considerable loft and low density, the fabric is easily cut, a fact of obvious importance in connection with the application and removal of the bandage.

A particularly important property of the fabric is its ability to adhere or cling to itself. This property is inherent in the material. It is not achieved as heretofore by impregnation with resins, rubber cements, and the like. The property, on use of the fabric as a bandage, completely eliminates the need of pins, clips, adhesive tape and other fastening means. Equally if not more important, it is unnecessary that each completed convolution of the wrap be held fast during the winding of the next succeeding convolution. Thus, in the case of orthopedic bandaging, the winding may be effectively and rapidly accomplished by a single individual as against at least two individuals normally required in the case of the prior constructions.

The conformability of the fabric, i. e., its ability when under slight tension to adjust itself to surfaces of irregular or changing contour, far exceeds that of previously used materials of which I am aware. Capacity to conform to irregular surfaces is of utmost importance in a material proposed for use in orthopedic bandaging.

Furthermore, due to its unusual conformability and self-adherence my fabric produces a wrap of very superior and remarkable qualities. The cling of the surfaces to each other effects a coherence of the overlays to produce substantially a unitary structure in which the layers resist displacement and shifting, and the structure as a whole is elasticly conformable.

In addition, and unlike conventional padding materials, my product per se exerts a gentle uniform pressure on the body member to which it is applied when used alone as a dressing, or as a padding under the conventional supportive materials. Thus, an improvement in circulation is effected with the primary dressing. In contrast to this, conventional inert and non-supportive padding materials, when applied under an elastic bandage or a rigid support, unevenly transmit the applied pressure to the affected member, and thereby create points of high pressure and impede circulation. So far as I am aware there is no other material that is suitable for use as a bandage or a padding which, of itself, plays a supportive role in improving circulation and thereby accelerating healing. This has been demonstrated to be a great advantage in the use of my material for the treatment of phlebitis, varicosities, leg ulcers, and the like.

The unwoven fabric herein is constituted entirely or for the most part of cotton fibers of textile length having artificially induced, irregular kinks, twists and bends and is further characterized in that it is dependent for its integrity on the intercurling of these fibers and in that the cotton textile fibers on at least one face of the fabric are in a perturbed state, the degree and nature of the perturbation being such that the surfaces brought together by folding the face upon itself cohere to each other or interlock. The perturbation of the fibers is produced by a mechanical working and most preferably by a controlled mechanical drafting or stretching operation.

A clear explanation of my invention requires reference to the subject matter of my co-pending

Patent No. 2,528,793, granted November 7, 1950. In that patent I describe a felt-like material produced from cotton textile fibers by shrinkage of a body of such fibers in an alkaline bath, the body normally representing a plurality of superposed webs such as are laid down by carding machines and the like. The material on being removed from the bath is in a highly wetted and softened condition. The surfaces thereof after the material has been dried, subsequent to suitable neutralizing and washing operations, are quite smooth and in an essentially "cast" condition. This condition obtains, in substantial degree, irrespective of the manner of processing the wet sheet, but it is particularly pronounced where the sheet is handled in the manner specifically described in the prior application and illustrated by the drawings. The cast surfaces do not interfere with use of the material in many fields; indeed such surfaces are actually advantageous in a number of applications, but for other purposes, as in bandage manufacture, for example, softer surfaces are generally desirable.

In considering ways to soften up the surfaces of the dried material, it occurred to me that this might be accomplished by slightly stretching the material. Accordingly, I wound a strip of the material on a roll and then transferred it by rewinding onto a second roll rotated at a faster rate than the first. On examination of the material from the second roll I found that the stretching did indeed cause marked softening of the surfaces. More important, I discovered that the stretching worked many other significant changes which could nowise be expected to follow from a simple controlled stretching of the material. Thus the stretching was accompanied by a substantial increase in thickness of the sheet rather than a decrease in thickness as would be expected. And perhaps most surprising, the strength was not greatly decreased.

Carrying my investigation further, I prepared two sheets according to the procedure of my identified co-pending application from carded webs which were in all respects identical. In the case of the first web I so controlled the conditions that an 80% shrink was obtained, i. e., the all over area of the dried sheet was 20% that of the starting web. I then mechanically stretched the dried sheet so that its area was 120% of the shrunken dried sheet. On comparison of the tensile strength of the stretched material with that of the product obtained from the second web which was not stretched but shrunk directly to the same area as that of the stretched sheet I found that the tensile strength of the first sheet in the direction of general fiber orientation was actually markedly greater than that of the second and that the crosswise tensile strength was not substantially reduced. Thus by the stretching procedure, I had succeeded in my original purpose of softening the cast surfaces, with the unexpected result of markedly increasing the strength in the direction in which the strength was important.

Carrying my researches still further, I found that the controlled stretching and the unpredictable decrease in density greatly increased the liquid retentiveness and air permeability of the product. These effects were perhaps to be expected from the decrease in density. However, on additional testing of the material with a view toward its use as an orthopedic wrap I discovered its ability to cling to itself and further discovered that the changes wrought in the fibers greatly increased the conformability of the material, clearly effects which would not be expected to follow from a procedure having mere softening of the surface as its objective.

The essential physical structure of the product herein differs markedly from that of the product of my prior application. However, my present product, like the prior product, is dependent for its integrity on the intercurled state of the constituent cotton fibers which are individually in a twisted, kinked, and bent condition deriving from the chemical shrinkage. Just what effect the stretching has on the fiber arrangement and relationship is not definitely known, although several plausible theories have been advanced. One theory is that the individual curled and kinked fibers originally associated in a tight foraminous network are, by the stretching process, caused to break away from their close frictional entanglement and to slide over one another and engage adjacent fibers. In the stretched condition the fibers assume another, but less closely associated, fibrous entanglement. During this fiber migration, the fibers near and at the surface, in part at least, break away from their original moorings and failing to engage other fibers, they form on the surface of the stretched material the kinky nap or pile rendering the fabric self-adherent. My invention is not, of course, predicated for its validity on the accuracy of this theory or on any other statements herein based solely on theory.

It must be understood that the "nap-like" surface of my non-woven material differs radically from the napped surface of flannels, velvets or other pile-like fabrics. The raised fibers of pile fabrics do not have pronounced curls, kinks, and bends and there is very little, if any, entanglement of the fibers. When two such surfaces are overlapped there is substantially no fibrous interlocking and mechanical bonding of the fibers per se. Further, since the napped fibers of such a fabric have but one free end, the other end being firmly anchored in a tightly twisted yarn of the woven structure, a stress applied to the free end of the fiber results in no displacement of the other end and no elastic movement of the fibrous unit as a whole. In my fabric, the fibers are nowhere immovably locked, nor are they adhesively secured to each other as are the fibers in conventional non-woven fabrics. Hence, a stress applied to the upper end of a surface fiber causes relocation of the lower end, which in turn causes a stretching or elastic displacement of all the surrounding fibers until such fibers develop sufficient mutual frictional entanglements to counterbalance the external stress. In other words, an external stress on a single fiber or group of fiber creates a response in the form of a positional readjustment of a multiplicity of fibers. The external stress is thereby distributed, and the fabric can withstand forces that would cause rupture if the fibers were twisted in yarns or imbedded in an adhesive matrix.

The change in area resulting from the mechanical drafting operation contemplated by the invention, which operation, of course, may be carried out using means other than the means previously indicated, may vary within substantial limits. The maximum permissible change in area is naturally related to the extent of the shrinkage obtaining on the wet treatment of the carded web, being usually less on the basis of the area of the carded web. I ordinarily do not increase the area of the shrunken sheet more than 45% (on the shrunken sheet). An area increase of from 5% to 30% is preferred for an orthopedic bandage, assuming a web representing at least a 60% area shrink. If the web is well shrunk, the strength of the web is maintained until the breaking point is quite closely approached. A stretch at least slightly exceeding the elastic limit is, of course, essential. The elastic limit will vary but is generally of the order of 4–8%.

While for many purposes the material may be stretched in either or both directions, in the case of bandaging materials the preferred method of stretching is lengthwise.

In addition to differential rollers, my invention may be practiced, for example, by passing the shrunken sheet through a button breaker or between rotating gears, drawing it over knife edges or bars of small diameter, etc., or by stretching laterally as in a tenter. In general, any equipment adapted to provide the desired changes, particularly the perturbation of the surface fibers, may be utilized.

The data provided by the table below were obtained from the comparative experiment previously referred to herein. The letter "A" in the table identifies a fabric produced in accordance with my prior invention from a carded web weighing 33 grams per square yard. The difference between the weight of the carded web and that of the fabric represented an area shrinkage of 80%. Fabric "B" was a fabric conforming to the present invention obtained by stretching fabric "A" lengthwise so as to obtain a 20.5% increase in area. Fabric "C" was produced by shrinking a carded web in all respects identical with the carded web from which fabric "A" was produced to an area essentially matching that of fabric "B."

Fabric	A	B	C
Shrink (area) ... percent	80	75.9	75.6
Wgt. per sq. yd. (grams)	165	137	135
Thickness [1]	.078	.103	.069
Apparent Density [2] ... gms./cc	.100	.063	.092
Softness [3] ... percent	13	37.4	19
Water Retentivity [4] ... do	800	1,050	800
Clingability [5]	0.9	1.8	1.1
Permeability [6]	173	280	193
Tensile [7]:			
Warpwise	6,450	6,580	5,670
Fillingwise	2,250	1,530	1,640
Total Elongation [8]:			
Warpwise ... percent	105	64	92
Fillingwise ... do	124	145	111

[1] *Thickness.*—Thickness was measured with a "dead load" dial micrometer. Under "no load conditions" the weight of the movement was 50 gms. on 1.74 square inches or 28.8 gms. per square inch.

[2] *Apparent density.*—Apparent density=weight per unit volume.

[3] *Softness.*—The thickness of the samples was measured with the "dead load" dial micrometer under "no load" conditions (28.8 gms./sq. in.) and with a weight of 500 gms. Softness is equal to the difference in thickness expressed as a percentage of the thickness under a 500 gm. load.

[4] *Water retentivity.*—Samples having an area of 4.06 sq. in. were immersed in water at 70° F. for 5 seconds. The samples were then removed, suspended from one corner for 10 seconds, and then weighed.

$$\text{Retentivity (in percent)} = \frac{\text{weight of water in wet sample}}{\text{weight of dry cotton in sample}} \times 100$$

[5] *Clingability.*—2″ x 20″ test samples were placed around a 2¼ inch diameter polished cylinder and overlapped 1½ inches. The overlap was sealed by applying a slight hand pressure. The core was suspended from one jaw of a tensile testing machine and the loop formed by the sample was placed in the other jaw. The clingability, in pounds, is equal to the force necessary to rupture the overlap.

[6] *Permeability.*—The permeability is the number of cubic feet of air that will pass through one square foot of material in one minute at a pressure differential of one half inch of water.

[7] *Tensile.*—Breaking length.

$$\text{Breaking length} = \frac{\text{breaking strength: lbs./in. width}}{\text{fabric weight: lbs./sq. in.}}$$

[8] *Total Elongation:*

$$\text{Elongation (in percent)} = \frac{\text{length at break—orig. length}}{\text{original length}} \times 100$$

All testing was done at standard conditions of 70° F. and 65% relative humidity.

The above table is submitted only by way of illustration and not by way of limitation, the values recited therein being subject to substantial variation without departure from the scope of the invention. I have previously indicated that for purposes of an orthopedic bandage I prefer a product stretched in the lengthwise direction, the product representing a 5–30% area increase on a sheet representing a shrinkage of at least 60% on the original carded web. Such a product will generally conform to the following limits:

Apparent density (gms./cc.)	0.03–0.12
Softness	20%–130%
Clingability	Greater than 1.3

Having thus described and illustrated the invention, what I claim is:

1. The method of making a non-woven, felt-like fabric which comprises chemically shrinking a shaped body consisting essentially of loosely integrated, unspun cotton textile fibers to an area less than about 40% of said shaped body and mechanically drafting the shrunken body to increase the area thereof from about 8 to about 45%, whereby the clingability, thickness, and softness of said shrunken body are substantially increased.

2. The method of making a non-woven, felt-like fabric which comprises chemically shrinking a shaped body consisting essentially of loosely integrated, unspun cotton textile fibers to an area less than about 40% of said shaped body and mechanically drafting the shrunken body in a substantially dry condition to increase the area thereof from about 8 to about 45%, whereby the clingability, thickness, and softness of said shrunken body are substantially increased.

3. The method of making a non-woven, felt-like fabric which comprises chemically shrinking an elongated sheet consisting essentially of loosely integrated, unspun cotton textile fibers to an area less than about 40% of said elongated sheet and, while the shrunken sheet is in a substantially dry condition, mechanically drafting the same in a lengthwise direction to increase the area thereof from about 8 to about 45%, whereby the clingability, thickness, and softness of said shrunken sheet are substantially increased.

4. A non-woven, felt-like fabric produced according to the process of claim 1.

5. A non-woven, felt-like fabric produced according to the process of claim 2.

6. A non-woven, felt-like fabric produced according to the process of claim 3.

HORACE A. SECRIST.

REFERENCES CITED

The following references are of record in the file of this patent:

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