

Aug. 3, 1971

F. K. MESEK ET AL
NONWOVEN FABRIC FORMED PREDOMINANTLY
OF SHORT LENGTH CELLULOSE FIBERS
Filed Feb. 9, 1968

3,597,306

Fig. 1.

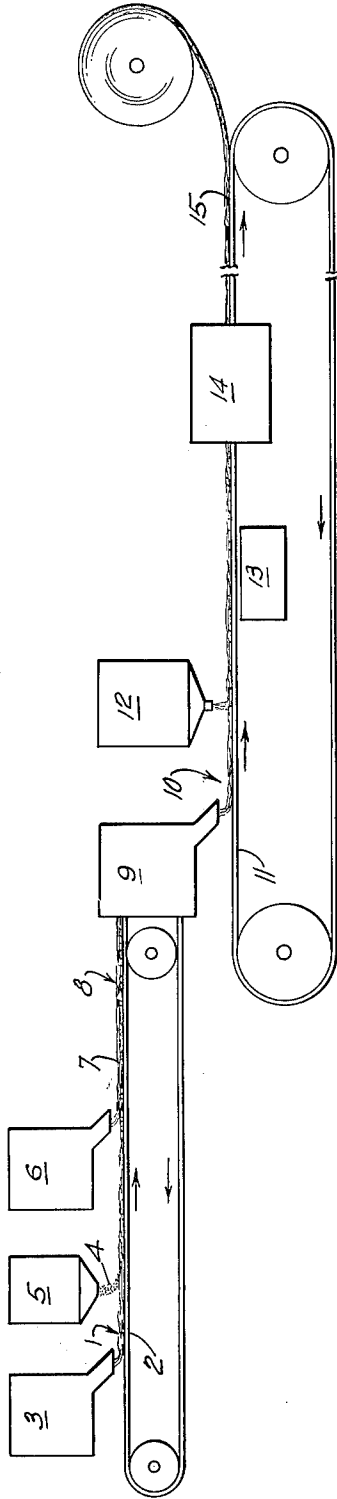


Fig. 4.



Fig. 3.

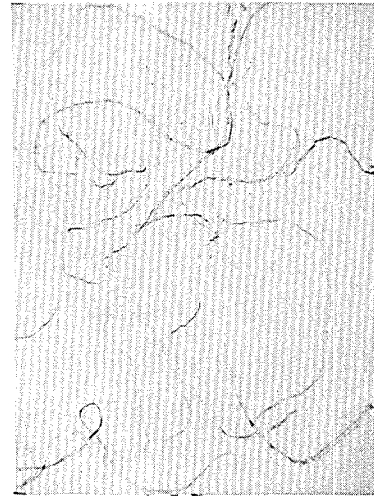
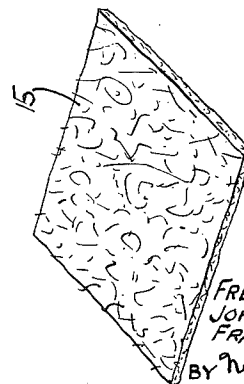


Fig. 2.



INVENTORS:
FREDERICK K. MESEK
JOHN S. ANDREWS
FRANK J. FILLWALK
BY Nicholas A. Kello, III

ATTORNEY

1

2

3,597,306 NONWOVEN FABRIC FORMED PREDOMINANTLY OF SHORT LENGTH CELLULOSE FIBERS

Frederick K. Mesek and John S. Andrews, Downers
Grove, and Frank J. Fillwalk, Oak Lawn, Ill., assignors
to Johnson & Johnson

Filed Feb. 9, 1968, Ser. No. 704,422

Int. Cl. B32b 5/16

U.S. Cl. 161—170

6 Claims

ABSTRACT OF THE DISCLOSURE

Through bonded nonwoven fabrics are disclosed which, based on the weight of fibrous material, consist of at least 80% by weight of cellulosic fibrous material of less than textile length. Of this short length cellulosic fibrous material, at least 15% and up to 50% by weight is particulate in nature. The fabrics have a minimum wet tensile strength of 0.61 pound per inch width, a minimum dry tensile strength of 1.35 pounds per inch width and a maximum stiffness of 7.0 cm.

BACKGROUND OF THE INVENTION

As a result of the recent sharp increase in the demand for disposable articles of apparel, the need, which has always existed, for a truly inexpensive nonwoven fabric possessing the strength, drape and hand of a woven fabric has become critical. While nonwoven fabrics which are considerably less expensive than woven fabrics have been developed, these conventional non-woven fabrics are generally still too costly to be utilized in or as one-use products such as diapers, surgical drapes, surgical gowns and the like.

The answer to the problem of producing inexpensive nonwoven fabrics resides in the utilization of predominately waste fibers and/or unrefined fibers rather than the "textile" fibers which have traditionally been employed to produce nonwoven fabrics. Unfortunately, these waste fibers and unrefined fibers, such as wood pulp and cotton linters, are usually of very short length; (i.e., less than 1/2 inch) and, due to past technological deficiencies, the preparation of nonwoven fabrics and fabric-like materials having the requisite strength, hand, and drape has been limited to the use of "textile length" fibers, that is, those fibers having a length well in excess of 1/2 inch.

For example, while wet layed fibrous webs, such as paper sheets and the like, often consist entirely of short cellulosic fibers such as wood pulp, as a result of the wet paper making process, the fibers are held together by virtue of hydrogen bonds and the resulting product is relatively stiff and dense and thus lacks the requisite drape of a substitute for woven fabrics. Short wood pulp fibers and the like have also previously been gathered together in a bulky cohesive mass and used in various products as a highly absorbent media. These materials are usually stabilized by a process which avoids the stiffening hydrogen bonds, however, they also have virtually no tensile strength, especially when wet, and because of their bulk they do not have the drape or hand of a fabric.

Thus, while attempts have been made to utilize short cellulosic fibers in the formation of fabric-like materials, the resulting products have been deficient in one or more requisite properties. No one has as yet produced a web consisting predominantly of these shorter fibers which has the combined strength, drape, and hand which is required and which is generally provided by nonwoven fabrics utilizing the longer textile length fibers.

As may be inferred from the above, many researchers have been attempting to discover how to produce fabric-like materials consisting predominantly of short

waste fibers and incorporating only minor amounts of textile length fibers. While these short fibers are, in fact, "short" (i.e., less than 1/2 inch in length), they nevertheless have a fiber-like structure in the traditional sense of the word. In general, no more than 10 to 15% of most wood pulp or cotton linters is so short as to pass through a 50 mesh screen when classified by the Clark Classification Procedure described in the test manual of the Technical Association of the Pulp and Paper Industry (TAPPI—T233—SU64). Only a much smaller amount, on the order of 4 to 8% is actually particulate in nature, that is, passes through a 100 mesh screen.

However, in carrying out our work on webs consisting predominantly of "short fibers," we have utilized large amounts of a material known in the industry as "wood flour." At least 40% of the "wood flour" we use will pass through a 100 mesh screen according to the above test, and at least 70% passes through a 50 mesh screen. "Wood flour" is available and has been used which will pass through a 100 mesh screen and 50 mesh screen to the extent of about 80% and 99% respectively. Thus, it can be seen that the short fibrous material with which we are working cannot be classified as having a "fiber" structure in the traditional sense of the word, but is in fact predominately particulate in nature. In this connection throughout the remainder of the specification and claims, when the term "fibrous material" is used, it refers to this particulate cellulosic material as well as to "fibers" in the traditional sense of a highly elongated thin filamentary material.

When working with "wood flour" or other highly particulate fibrous material, the problems encountered in providing a web having the requisite fabric-like properties described earlier are substantially more acute than when working with materials which have a definite fiber structure. Only board-like products have heretofore been made of "wood flour." In addition, it is widely known that "wood flour" by itself possesses essentially no absorbency. Therefore, few have even hoped of providing an absorbent product having fabric-like properties incorporating large amounts of "wood flour."

THE INVENTION (GENERAL)

We have now found that non-woven fabrics having good wet and dry tensile strength, absorbency, drape and hand, may be provided while utilizing substantial amounts of "wood flour," that is substantial amounts of particulate cellulosic material. Apparently, when the particulate cellulosic material is utilized in a binder stabilized web with cellulosic material having a definite fiber structure, the fibers retain the "wood flour" in the fabric as an integral part of the same and absorbent cells are created.

In particular, the fabrics of this invention are through bonded, nonwoven fabrics in which the fibrous material consists predominantly, that is, from about 80% to 95%, of fibrous, cellulosic material having a length of no greater than about 1/2 inch. The fibrous material also consists of from 5% to 20% textile length cellulosic fibers. Most importantly, of the fibrous material of less than 1/2 inch in length, at least 15%, preferably at least 20%, and up to 35% or 50% or more consists of particulate, cellulosic material, that is, material which passes through a 100 mesh screen. The fabrics have a dry Instron tensile strength of at least 1.35 pounds per inch width, a wet Instron tensile strength of at least 0.61 pound per inch width, a stiffness (drape) according to ASTM D1388 of (at least) no more than 7.0 centimeters, and a water-holding capacity generally above 1,000% according to the 60-second drain test, for a fabric having a weight based on fibrous material of 3 oz./yd.². In this latter test, a weighed sample of the fabric is immersed in a water bath having an outlet

3

in the side at the bottom. After 60 seconds the bath is tilted at 45° and the water therefrom allowed to drain. The sample is subsequently weighed, and the difference expressed in percentage is the water-holding capacity.

The invention will be better understood by reference to the attached drawing and the descriptions thereof set out below:

THE INVENTION (DETAIL)

In the drawing, FIG. 1 is a schematic representation of the formation of the fabrics of this invention.

FIG. 2 is a view in perspective of such a fabric.

FIG. 3 is a 25 power photomicrograph of a sample of soft alpha M wood pulp and,

FIG. 4 is a 25 power photomicrograph of a sample of "140 mesh" wood flour.

In order to understand the invention, it is first necessary to fully understand the difference between short cellulosic fibers, such as wood pulp, and particulate cellulose material such as "wood flour." Referring to FIG. 3, there appears a 25 power photomicrograph of soft alpha M wood pulp. The field of view in the photomicrograph is 3.37 mm. in the lengthwise direction. As can be seen by inspection of the photomicrograph, the wood pulp has a definite fiber structure. However, the "wood flour" sample shown in a similar photomicrograph as FIG. 4, definitely does not have a fiber structure. The "longest" wood flour particle appearing in the photomicrograph is about 220 microns "long" while the shortest wood pulp fiber appears to be about 800 microns long. Only 7.4% of the wood pulp shown passes through a 100 mesh screen and only 11% passes through a 50 mesh screen while 79.8% and 99% of the "wood flour" passes through a 100 and 50 mesh screen respectively.

(A) TEXTILE LENGTH CELLULOSE FIBERS

Any textile length (i.e., of greater than ½ inch) cellulosic fiber may be utilized, however, for reasons of economy and availability, 1½" staple rayon is preferred. As noted immediately above, the textile length fibers may be present in the web in an amount of from as little as 5 to no more than about 20% by weight of fibrous material. In addition to imparting added tensile strength to the web, these fibers also cooperate in forming the absorbent cells which are essential to the use of the fabric in or as absorbent dressings, diapers and the like.

The quantity of textile length fibers used depends directly on the amount of particulate material incorporated into the web. This in turn, for all practical purposes, depends on the amount and classification of the "wood flour" utilized although a small amount of particulate material may be introduced in the wood pulp or linters as shown by the classification results referred to earlier.

When the particulate material is present in small amounts, that is from 15 to 20% by weight of fibrous material of less than ½ inch in length, no more than about 5% textile length fibers by weight of fibrous material will be required to meet the minimum fabric properties outlined earlier. Of course, a higher percentage of textile length fibers can be utilized if desired to further increase the tensile strength of the web, however, for reasons of economy this will usually not be done. Where the particulate material is present in amounts as high as 50% by weight of fibrous material of less than ½ inch in length, no more than 17 to 20% textile length fibers by weight of fibrous material will be required. The remainder of the fibrous material, that is 80% or more, is less than ½ inch in length. This is divided between short cellulosic fibers and particulate material.

(B) PARTICULATE CELLULOSIC MATERIAL

As should be apparent, for reasons of economy, it is desirable to utilize large amounts, and at least 15% by weight of fibrous material of less than ½ inch in length, of particulate cellulosic material in the webs of this invention. It is not generally practical to incorporate more

4

than about 50% particulate cellulosic material by weight of fibrous material of less than ½ inch in length in that amounts in excess of this are very difficult to retain integrally dispersed within the web. Particulate, cellulosic material in amounts up to and including this level, may be used to form satisfactory webs. Generally, from 25 to 40% of the fibrous material of less than ½ inch in length in these webs will be particulate in nature. The material sold in the trade generally as "wood flour" has various trade designations from "40 mesh" to "140 mesh." Approximately 42% of "40 mesh" wood flour passes through a 100 mesh screen and is therefore particulate in nature while 80% of "140 mesh" wood flour passes through a 100 mesh screen. Thus, greater or lesser amounts of "wood flour" will be used to provide a given level of particulate material depending on the "wood flour" chosen. Both hard and soft "wood flour" is available and it has been found to be preferable to utilize soft "wood flour" when a fabric with fairly good hand and drape is required.

As also noted above, from 4 to 9% of wood pulp or second cut linters is particulate in nature. Therefore, the Clarke Classification of the pulp or linters used will be taken into account when calculating the relative amounts of "wood flour" and pulp to use in the webs of this invention.

(C) SHORT CELLULOSIC FIBERS

The remainder, i.e., from 50 to 85%, of the fibrous material of less than ½ inch in length consists of short cellulosic fibers such as the portion of wood pulp and second cut cotton linters which are retained by a 100 mesh or denser screen. In general, wood pulp and second cut cotton linters have a fiber length within the range of about ¼-¾ inch with the average fiber length being about ½ inch. Any of the wood pulp or cotton linters commonly commercially available are satisfactory for use in a web of this invention.

(D) BINDER

While the amount of binder will generally vary between about 2 and about 6% dry solids pick-up, more or less binder can be utilized when the properties desired in the completed fabric vary from those discussed earlier. Where binder in amounts greater than 6% dry solids pick-up is utilized, the resulting web tends to be somewhat stiff. However, this can be offset by applying various finishing treatments to the stabilized fabric. These finishing treatments which tend to impart drape and hand to the fabric include compacting, Clupaking, embossing and the like. Thus, in order to provide a fabric which has a substantially higher tensile strength, one might use as much as 10 or 12% binder based on dry solids pick-up and thereafter emboss the completed web. While any binder system may be used, depending somewhat on the properties desired in the final product, self-curing acrylic latex binders are preferred.

When using these binders, the same apparently sufficiently coats enough individual fibers to interfere somewhat with their normal water absorbent characteristics. Therefore, it may be necessary to treat the fabric with a rewritten agent such as, for example, an anionic sulfonated alkyl ester. These rewetting agents may be included in the binder solution and by thus including the agent at this step in the manufacture, the resulting fabrics are found to be readily wettable and highly absorbent.

(E) PROPERTIES OF THE COMPLETED WEB

Webs having a weight from about 2 to about 9 ounces per square yard may be produced according to this invention. Generally, the webs produced will have a thickness not exceeding about ¼ inch as webs much thicker than this tend to lack the requisite drape and hand. The absorbent capacity of the webs will, of course, depend

5

somewhat on their density, but in general, it will vary between about 1000 and 1300%. As pointed out earlier, the stiffness (drape) of the fabric is no more than (at least) about 7.0 and preferably 3.5 cm. according to ASTM D1388, the wet Instron tensile strength at least 0.61 pound per inch width and the dry Instron tensile strength at least 1.35 pounds per inch width. However, the stiffness (drape) as well as the tensile strength of the fabrics may be varied, as noted above, by controlling the amount of binder utilized and/or the finishing treatments applied to the stabilized webs.

METHOD OF MANUFACTURE

Referring now to FIG. 1, in producing the fabrics of this invention a homogeneous dry web, 1, consisting mostly of short fibers, such as wood pulp or second cut cotton linters, with small amounts of textile length cellulosic fibers, such staple rayon, is formed on a moving conveyor 2. This is suitably done by first mixing the wood pulp and rayon fibers and then disposing them in an air-stream which passes through a foraminous moving screen, the fibers being collected on the screen to form the web. This may be accomplished by using an air-laying machine 3 such as the "Rando-Webber" made and sold by the Curalator Co.

A layer of predominately particulate cellulosic material, such as "wood flour" 4 is then applied to the exposed surface of the previously formed web 1 by a sifter 5 or the like. The "wood flour" is subsequently covered by a second dry web 7 consisting mostly of short fibers with small amounts of textile length fibers and which is formed on a second web-forming machine 6. The sandwich 8 of fibers 1 predominately particulate material 4 and fibers 7 is fed into still another air-laying web forming apparatus 9 again suitably the "Rando-Webber" or the like, and a dry unbonded web 10 formed in which the wood flour is relatively uniformly dispersed among the fibers.

The formation of a relatively homogeneous dry web is critical to the manufacture of the fabrics of this invention. Thus, it is essential to uniformly disperse the particulate material among the fibers. It has been found that this cannot be accomplished by merely sifting the particulate material on top of and thence into a previously formed web of the fibers; nor can it be accomplished by introducing a web of the fibers and a layer of the particulate material into the initial fiber laying machine. When this latter approach is attempted, large amounts of the particulate material tend to gravitate to the bottom of the fiber laying machine instead of being dispersed within the web. However, by utilizing the method described above, the particulate material is contained between two layers of fibers, and as the sandwich enters the air stream of the fiber laying apparatus 9 the particulate material and the fibers are apparently blended in the air stream of the fiber laying machine 9 thus resulting in the homogeneous web 10.

After the dry unbonded web 10 is formed, the same is impregnated with a binder, suitably by first applying a solution or dispersion of the binder 12 to the surface of the web and thereafter passing the web over suction slot 13 to remove excess binder and assure uniform distribution of the binder throughout the web. This impregnation of the web by binder followed by suction is known in the art as suction bonding. However, any suitable method of binding, i.e. mangle bonding or spray bonding, could be utilized instead of suction bonding. Following impregnation of the web and the suction treatment the web should have a binder pick-up of from about 2 to about 6% dry solids add-on by weight of the web.

The web thus formed is then dried in an oven, 14, at a temperature from about 330 to 355° F. to remove the solvent for the binder and to cure the binder. The finished fabric 15 is then wound on a roll and is ready

6

for use. A section of the fabric 15 formed as illustrated in FIG. 1 is shown in FIG. 2 of the drawings.

MISCELLANEOUS VARIATIONS AND ADDITIONS

Because of the short fibers used in this construction the scuff resistance of the fabrics of this invention may conceivably be unsatisfactory for some uses. It has been found, however, that the scuff resistance can be substantially improved by forming a thin veneer of textile length fibers on the surface of the fabric or by print bonding the surface of the fabric with a binder in a pattern of spaced bonding lines.

Where a veneer of textile length fibers is used, those fibers would be laid on one or both surface of the web prior to the bonding step. The amount of textile length fibers used is generally no more than about 100 grams per square yard, and such a veneer would form no more than about 10 to 20% of the total fiber weight of the web. After the veneer and base web are aligned, the composite sheet would be suction bonded in the manner previously described and the web again dried.

Where scuff resistance is imparted through surface printing, the surface of the web is printed with the surface binder while the web is wet. The printing is usually done by conventional print bonding rolls and the bonding lines preferably run across the width of the materials spaced about 1/8 to 1/4" from each other. The printing is controlled to give a printing resin content on the dry basis of about 55-65 grams per square yard.

In order to assist in the duplication of the fabrics of this invention, one working example is provided below:

A fibrous web composed of 25% 1.5 denier, 1 1/4 staple rayon fibers and 75% Weyerhaeuser Soft Alpha M wood pulp is formed on a web laying device at a weight of 4 ounces per square yard. A 6-ounce per square yard layer of 140 mesh soft "wood flour" is sifted onto the surface of the first web. A second fibrous web having a weight of 2 ounces per square yard and the same fiber composition as the first web is disposed on top of the layer of wood flour to form a sandwich. The composite of fibers, wood flour and fibers is the input for another air laying device and a homogeneous web is formed at a weight of 3 ounces per square yard.

This web is then conveyed through a suction bonding unit in the manner previously described and stabilized with a self-cross-linking acrylic emulsion containing 0.03% of a sulfonated alkyl ester rewetting agent. The solids composition of the binder emulsion is 2.5% and the amount of suction at the suction slot is controlled so as to give the fabric a dry solids add-on of 5% based on the weight of fibrous material. The wet web is conveyed into a drying oven having a temperature of 330-350° F. where it is dried and the resin cured.

On a fiber basis the resultant fabric consists of 12.5% textile length cellulosic fibers and 87.5% fibrous cellulosic material (wood pulp and wood flour) having a length of less than 1/2 inch. Of the fibrous material having a length of less than 1/2 inch, 57% is derived from the wood flour and 43% is derived from the wood pulp. Also 80% of the pulp and 7.4% of the wood flour passes through a 100 mesh screen when subjected to the Clarke classification. Therefore, of the fibrous material having a length of less than 1/2 inch, 49.3% is particulate in nature.

The completed fabric has stiffness (drape) according to ASTM Test D1388 of 3.3 cm. and an absorbent capacity according to the 60-second drain test of 1,240%. The web also has a dry Instron tensile in the machine direction of 1.35 pounds per inch width and a wet Instron tensile in the same direction of 0.61 pound per inch.

What is claimed is:

1. A through bonded nonwoven fabric having a weight of from 2 to 9 ounces per square yard which, based on weight of fibrous material, consists predominantly of fibrous cellulosic material of short length,

7

no greater than 20% by weight of said fibrous material consisting of cellulosic fibers having a length substantially greater than about $\frac{1}{2}$ inch, the remainder of said fibrous material consisting of cellulosic fibrous material having a length of less than about $\frac{1}{2}$ inch, said cellulosic fibrous material having a length of less than about $\frac{1}{2}$ inch in turn consisting of at least 15% by weight of particulate cellulosic material, said particulate material having a particle size small enough to pass through a 100 mesh screen, said fabric having a dry tensile strength of no less than about 1.35 pounds per inch width, a wet tensile strength of no less than about 0.61 pound per inch width and a stiffness of no greater than 7.0 cm. for a web having a weight based on fibrous material of 3 ounces per yard² and having an absorbent capacity of at least 1000 percent.

2. A fabric of claim 1 in which said cellulosic fibrous material having a length of less than $\frac{1}{2}$ inch consists of at least 25% by weight of particulate cellulosic material.

3. A fabric of claim 2 in which said cellulosic fibrous material having a length of less than $\frac{1}{2}$ inch consists of at least 35% by weight of particulate cellulosic material.

8

4. A fabric of claim 2 in which said cellulosic fibrous material having a length of less than $\frac{1}{2}$ inch consists of at least 50% by weight of particulate cellulosic material.

5. A fabric of claim 1 in which said web has a stiffness of no greater than 3.5 cm.

6. A fabric of claim 4 in which said web has a stiffness of no greater than 3.5 cm.

References Cited

UNITED STATES PATENTS

2,647,297	8/1953	Battista	161—170
3,007,840	11/1961	Wilcox	161—170
3,317,367	5/1967	Koller	161—158
3,377,232	4/1968	Meacock et al.	161—170
2,005,638	6/1935	Schacht	161—158
2,198,232	4/1940	Shopneck	162—149
2,881,669	4/1959	Thomas et al.	162—149

MORRIS SUSSMAN, Primary Examiner

U.S. Cl. X.R.

161—158, 168; 162—149