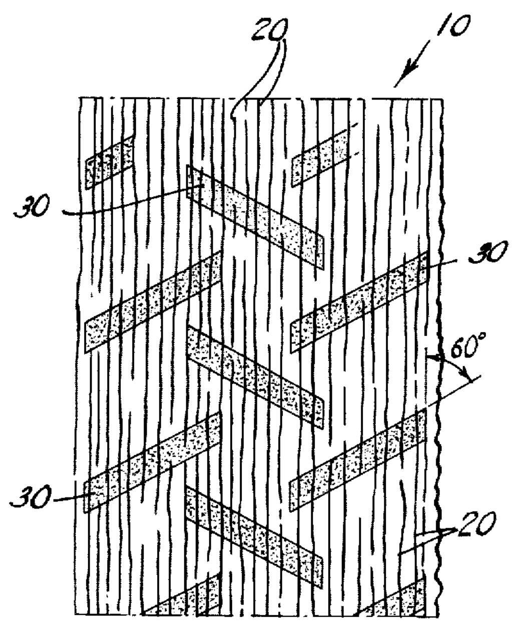
April 30, 1963 A. H. DRELICH 3,087,833

FIBROUS STRUCTURES AND METHODS OF MAKING THE SAME

Filed Jan. 19, 1961



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United States Patent Office

3,087,833

Patented Apr. 30, 1963

3,087,833

FIBROUS STRUCTURES AND METHODS OF MAKING THE SAME

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Filed Jan. 19, 1961, Ser. No. 83,793
5 Claims. (Cl. 117—38)

The present invention relates to fibrous structures bonded with hydroxyethyl cellulose binders and to methods of making the same. More particularly, the present invention is concerned with nonwoven fabrics bonded with hydroxyethyl cellulose binders and to methods of making the same whereby they are soft and drapeable and non-pilling and non-fuzzing, even after washing or laundering.

Although not limited thereto, the invention is of primary importance in connection with nonwoven fabrics formed from card webs of textile fibers, the major proportion of such textile fibers being oriented predominantly in one direction. Typical of such nonwoven fabrics are the so-called "Masslinn" nonwoven fabrics, some of which are described in greater particularity in U.S. Patents 2,705,687 and 2,705,688 which issued April 5, 1955, to De Witt R. Petterson et al. and Irving S. Ness et al., respectively.

Another aspect of the present invention is its application to nonwoven fabrics wherein the fibers are basically predominantly oriented in one direction but are also reorganized and rearranged in predetermined designs and patterns of fabric openings and fiber bundles. Typical of such nonwoven fabrics are the so-called "Keybak" bundled fabrics, some of which may be produced by methods and with apparatus more particularly described in U.S. Patent 2,862,251, which issued December 2, 1958, to Frank Kalwaites.

Still another aspect of the present invention is its application to nonwoven fabrics wherein the fibers are disposed at random and are not predominantly oriented in any one direction. Typical of such nonwoven fabrics are the so-called "isotropic" nonwoven fabrics, some of which may be produced by methods and with apparatus more particularly described in U.S. Patents 2,676,363 and 2,676,364 which issued April 27, 1954, to Charles H. Plummer. Other examples of typical "isotropic" nonwoven fabrics wherein the fibers are not predominantly oriented in any one direction are those made by modified papermaking techniques.

Nonwoven fabrics made by any of the above-described or equivalent methods and apparatus have become increasingly important in the textile and related industries, primarily because of their low cost of manufacture for a given coverage, as compared to the cost of more conventional textile fabrics made by weaving and knitting operations. Examples of uses for such nonwoven fabrics are wrapping and packaging materials, surgical dressings and bandages, covers or other components of sanitary napkins, hospital caps, dental bibs, eye pads, dress shields, diapers and diaper liners, casket liners, wash cloths, hand and face towels, handkerchiefs, table cloths and napkins, curtains and draperies, quilting or padding, cleaning materials, shoe shine cloths, battery separators, air or other filters, etc. Because of this wide variety of usés, these nonwoven fabrics are available commercially in a wide range of fabric weights of from as little as about 140 grains per square yard to as much as about 3000 or more grains per square yard.

Fabric stability and strength are usually created in such nonwoven fabrics by bonding with adhesive or cementitious materials. The bonding operation employed for

stabilizing and strengthening nonwoven fabrics has taken on many forms, one popular form being the intermittent bonding of the nonwoven fabric with a predetermined pattern of spaced, discrete binder segments, such as areas or lines extending across the width of the nonwoven fabric. The individual fibers passing through these binder segments are thus adhered into a stable, self-sustaining relationship. The binder segments may take on any desired shape or form including lines, circles, annuli, ovals, ellipses, triangles, rectangles, squares, diamonds, parallelograms, or other polygons, or combinations of such forms, either regularly or irregularly shaped. The binder segments may extend across the nonwoven fabric at any desired angle to the long axis; the binder lines may be parallel, or they may cross each other to form diamond or irregular polygonic figures; the binder lines may be continuous or discontinuous; or they may be straight, curved, sinuous, or irregularly wavy.

One common factor, however, is to be particularly noted in all of these patterns, namely, that the total surface coverage of the binder segments on the nonwoven fabric should not exceed about 50% of the total surface of the nonwoven fabric. Preferably, such coverage should be less than about 35% and may be down to about 12% or even 7% of the total surface of the nonwoven fabric.

Substantially all prior art nonwoven fabrics, regardless of their method of manufacture or of the particular bonding techniques employed, however, have usually suffered from certain inherent disadvantages and weaknesses which have militated against their more widespread acceptance and use by the industry and the ultimate consumer.

For example, nonwoven fabrics bonded with hydroxyethyl cellulose binders have been made hitherto but have never received complete commercial acceptance. When the hydroxyethyl cellulose was used as an over-all impregnant, the resulting product was not soft or drapeable but in many cases was actually undesirably harsh and stiff. When the hydroxyethyl cellulose was printed on the nonwoven fabric in an intermittent binder pattern, the resulting product was relatively soft and drapeable but severely pilled and fuzzed and on many occasions even disintegrated on washing and laundering.

It is a principal purpose of the present invention to provide a hydroxyethyl cellulose bonded fibrous structure which is soft and drapeable and which is substantially and practically non-pilling and non-fuzzing, even after washing and laundering.

It has been discovered that such a soft and drapeable, bonded fibrous structure which is practically non-pilling and non-fuzzing, even after washing and laundering, may be made by printing the fibrous structure in a predetermined pattern of spaced areas or lines with an alkaline hydroxyethyl cellulose solution having a viscosity of from about 450 centipoises to about 2000 centipoises and a caustic content of from about 6% to about 9½%, and then coagulating the hydroxyethyl cellulose, for example, in an aqueous medium, into an alkali-soluble, water-insoluble form wherein it is capable of functioning as a binder, whereby a soft and drapeable, print-pattern bonded fibrous structure is obtained which is practically non-pilling and non-fuzzing, even after washing and laundering.

The predetermined pattern of spaced binder areas or lines is substantially as described hereinbefore. Reference is made to U.S. Patents 2,705,687; 2,705,688; 2,705,498 and particularly 2,880,111 for more specific geometric details.

The viscosity of the alkaline hydroxyethyl solution is critical and the solution must carefully prepared so that the viscosity falls within the range of from about 450 centipoises to about 2000 centipoises when measured at

75° F. (Brookfield viscosimeter, No. 3 spindle, 30 r.p.m.). Preferably, a narrower range of from about 600 centipoises to about 1500 centipoises is employed. These extremely low ranges are all the more surprising when it is noted that the viscosity range for printing with viscose solutions is very high and is from about 5000 centipoises to about 10,000 centipoises.

Similarly, the caustic content (sodium hydroxide content) of the hydroxyethyl cellulose solution is critical and the acceptable range extends from about 6% up to about 9½%. Failure to keep within this range creates serious difficulties. For example, the use of a caustic content below this range prevents good penetration of the binder and creates extreme pilling and fuzzing of the bonded fibrous structure on washing and laundering. Preferably, the caustic content is in the range of from about 7% to about 9%.

The degree of etherification of the hydroxyethyl cellulose is important and a degree of substitution equivalent to an ethylene oxide content of from about 2% to about 5% by weight, and preferably from about 3½% to about 4½% by weight, is used in order to provide the desired and required properties and characteristics. Optimum results are obtainable at an ethylene oxide content of about 4% by weight.

The percentages of ethylene oxide content refer, of course, to the percentages, by weight, of combined ethylene oxide in the hydroxyethyl cellulose. It is a percentage by weight, rather than a percentage by numbers, which is used occasionally in the industry to indicate the numerical percentage of the free hydroxyl groups which have been substituted or etherified. This latter numerical percentage is occasionally referred to in the industry as the degree of substitution.

In addition to the low degree of etherification of from about 2% to about 5% being critical, it is also important that the etherification take place extremely uniformly along the cellulose chain. Unless such uniformity is obtained, solutions of low caustic concentrations (3½%–4½%) of the resulting hydroxyethyl cellulose contain microscopic or submicroscopic particles and are clouded and not clear. Such solutions are to be contrasted to the clear, unclouded solutions of hydroxyethyl cellulose of the present invention in caustic solutions having concentrations as low as about 3½% or 4%. In order to obtain such extreme uniformity of substitution, it is necessary that both the alkalization of the original cellulose to alkali cellulose and the etherification thereof with ethylene oxide or equivalent procedure be carried out in as uniform a manner as possible. Specific procedures for carrying out such uniform alkalizations and etherifications are described in U.S. Patent 2,847,411 which issued August 12, 1958, and reference thereto is incorporated herein.

The degree of polymerization of the hydroxyethyl cellulose is also of importance and it has been found that a degree of polymerization of from about 250 to about 1000 anhydroglucose units, and preferably from about 270 to about 600 anhydroglucose units, is desired. Optimum results are obtainable at a degree of polymerization of about 325 to about 400 anhydroglucose units.

The invention will be further illustrated and described in greater detail by reference to the accompany drawing and following specification wherein there is illustrated and described a preferred embodiment of the invention. It is to be understood, however, that the invention is not to be considered limited to the embodiment disclosed except as determined by the scope of the appended claims.

Referring to the accompanying drawing the FIGURE is a plan view on an enlarged scale diagrammatically showing a portion of a nonwoven fabric bonded with a hydroxyethyl cellulose binder pattern in accordance with an embodiment of the present invention.

In the embodiment of the invention shown in the figure, the fibrous structure comprises a nonwoven fabric **10** comprising a layer of overlapping, intersecting fibers **20** which have been bonded together by means of hydroxyethyl cellulose binder segments **30** distributed thereon in a predetermined, elongated cross-hatch pattern comprising a multiplicity of spaced, discrete binder segments.

In the following description of the invention, reference will be made primarily to fibrous structures comprising natural and synthetic fibers such as cotton and regenerated cellulose, notably viscose rayon. It is to be noted that the fibrous structure may also contain other natural or synthetic, vegetable, animal or mineral fibers such as silk, wool, flax, etc.; synthetic or man-made fibers such as cross-linked cellulosic fibers such as "Corval" and "Topel"; cellulose ester fibers such as cellulose acetate ("Celanese") and cellulose tri-acetate ("Arnel"); the saponified cellulose ester fibers sch as "Fortisan" and "Fortisan-36"; the polyamide fibers such as nylon 6 (polycaprolactam), nylon 66 (hexamethylene diamine-adipic acid); polyester fibers such as "Kodel" and "Dacron"; vinyl fibers such as "Vinyon" and saran; acrylic fibers such as "Orlon," "Acrilan," "Creslan," etc.; modacrylic fibers such as "Dynel" and "Verel"; etc.

The lengths of the fibers in the starting fibrous structure may vary from about ⅜ inch or ½ inch up to about 2½ inches or more in length, depending upon the particular properties and characteristics required or desired in the resulting fibrous nonwoven product. If desired, the fibrous structure may have added thereto, by a subsequent processing step, if necessary, from about 1 or 2% by weight up to about 100% by weight of fibers other than those of textile length. In special cases, all of the textile length fibers may be replaced by fibers other than of textile length. These other fibers may be of papermaking length, which extend from about ⅜ inch in length down to about 1/16 of an inch or less in length, which shorter fibers normally are not used in conventional methods of producing fibrous nonwoven products.

Illustrative of these short papermaking fibers are the natural cellulosic fibers such as woodpulp and wood fibers, cotton linters, etc., or any of the hereinbefore-mentioned natural or synthetic fibers in lengths less than about ⅜ inch and down to about 1/16 of an inch or less.

The denier of the individual synthetic fibers referred to above is preferably in the range of the approximate thickness of the natural fibers mentioned and consequently deniers in the range of from about 1 to about 5 are preferred. Where greater opacity or greater covering power is desired, special fiber deniers of down to about ¾ or even about ½ may be employed. Where desired, deniers of up to about 8, 10, 15, or higher may be used. The minimum and maximum denier are naturally dictated by the desires or requirements for producing a particular fibrous web, by the machines and methods for producing the same, and so forth.

The weight of the starting fibrous structure may be varied within relatively wide limits above a predetermined minimum value, depending upon the requirements of the intermediate or the final products. A single, thin web of fibers, such as produced by a card, may have a weight of from about 35 to about 250 or more grains per square yard and may be used in the application of the principles of the present invention. Within the more commercial aspects of the present invention, however, laminated web weights of from about 140 grains per square yard to about 3000 grains per square yard are contemplated. The product of one card may be folded, doubled, tripled, etc., on itself to reach the heavier weight, or a plurality of cards may be used and the individual products stacked or laminated for a similar purpose.

As mentioned previously, the total surface coverage of the binder areas or lines on the fibrous structure should not substantially exceed about 50% or the total surface of the fibrous structure. Preferably, such binder coverage should be less than about 35% and down to about 7%, and preferably down to only 12%, of the total surface of the fibrous structure.

The amount of binder add-on of hydroxyethyl cellulose required to satisfactorily bond the fibrous structure may range from as little as about 1% to as high as about 10% and preferably, from about 1½% to about 7%, by weight, based on the weight of the dry fibrous structure being bonded.

The invention will be further illustrated in greater detail by the following specific examples. It should be understood, however, that although these examples may describe in particular detail some of the more specific features of the invention, they are given primarily for purposes of illustration and the invention in its broader aspects is not to be construed as limited thereto.

Example I

A 100% all-rayon card web weighing about 600 grains per square yard and comprising 1.5 denier, 1$^{9}/_{16}$ inch staple length viscose rayon fibers is printed with an alkaline solution of hydroxyethyl cellulose having a hydroxyethyl cellulose content of 6.2%, a sodium hydroxide content of 8%, and a viscosity of 750 centipoises (Brookfield) at 75° F. The hydroxyethyl cellulose has a chain length of 325 anhydroglucose units and its ethylene oxide content is 4% by weight. Etherification is extremely uniform along the cellulose chain. A small amount of colored pigment is added to the hydroxyethyl solution so that the disposition of the binder can be clearly seen in the final product.

The print pattern is an elongated cross-hatch pattern with the length of each binder segment being 0.200 inch and its width 0.034 inch and a binder coverage of about 24%. The axes of the cross-hatch binder segments are 60° to the long axis of the card web.

After printing, the applied hydroxyethyl cellulose solution is coagulated in dilute aqueous sulfuric acid (3%) at ambient temperature, washed well to remove all excess acid, salts, etc., and the resulting bonded card web is dried and carefully examined. It is relatively soft and drapeable. The binder migration control is excellent and the binder penetration through the web to its back side is essentially complete. The bonded card web successfully withstands ten standard home laundering cycles in a "Bendix" washing machine with only little damage.

Example II

The procedures of Example I are carried out substantially as set forth therein with the exception that 50% by weight of the viscose rayon fibers is replaced with cotton fibers. The remainder of the procedure is as described therein and the results are comparable. The bonded fibrous structure is commercially acceptable.

Examples III and IV

The procedures of Example I are carried out substantially as set forth therein with the exception that the viscosity of the hydroxyethyl cellulose solution is changed by modifying the procedures involved in its preparation so that the resulting viscosity is (*a*) 600 centipoises with the caustic content remaining at 8% and (*b*) 1150 centipoises with the caustic content being changed to 9%. Coagulation is in dilute sulfuric acid (3%) and the remainder of the procedure is relatively unchanged. The results are comparable. The bonded fibrous structure is commercially acceptable.

Example V

The procedures of Example I are carried out substantially as set forth therein with the exception that the coagulation of the hydroxyethyl cellulose solution takes place in hot water at a temperature around 210° F. The results are comparable. The bonded fibrous structure is commercially acceptable.

Example VI

The procedures of Example I are carried out substantially as described therein with the exception that the viscosity of the hydroxyethyl cellulose solution used is 5000 centipoises, corresponding to 37 seconds by the ball fall test used in the viscose industry. This value is above the viscosity range of the present inventive concept. Also, the caustic content is 6.85% and the hydroxyethyl cellulose solids content is 7.9%. A small amount of colored pigment is added to the hydroxyethyl cellulose solution so that its distribution in the final product can be easily seen. Coagulation is in dilute sulfuric acid.

The binder penetration is not satisfactory; there is complete penetration of the binder to the back side of the fabric. The fabric pills badly after only 1 laundering cycle. The bonded fabric is not acceptable commercially.

Example VII

The procedures of Example I are carried out substantially as set forth therein with the exception that the preparation of the hydroxyethyl cellulose solution is such that the resulting viscosity is 1000 centipoises and the caustic content is 5½% which is outside the range of the present inventive concept. Penetration of the binder is incomplete and the bonded fabric cannot be satisfactorily laundered. The bonded fibrous structure is not commercially acceptable.

Although several specific examples of the inventive concept have been described, the same should not be construed as limited thereby nor to the specific features mentioned therein but to include various other equivalent features as set forth in the claims appended hereto. It is understood that any suitable changes, modifications and variations may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A method of making an intermittently bonded nonwoven fabric, which is practically non-pilling in washing and laundering, which comprises: forming a layer of overlapping, intersecting fibers; printing the layer in a predetermined pattern of spaced segments penetrating substantially through the thickness of said layer from one surface thereof to the other surface with an alkaline solution of hydroxyethyl cellulose having a viscosity of from about 450 to about 2000 centipoises and a caustic content of from about 6% to about 9½%, said hydroxyethyl cellulose having an ethylene oxide content of from about 2% to about 5% by weight, said ethylene oxide being substantially uniformly distributed throughout the cellulose molecule, and said hydroxyethyl cellulose having a degree of polymerization of from about 250 to about 1000 and being water-insouble; and coagulating said hydroxyethyl cellulose solution while the same is in the aforesaid printed form to deposit on and in the fabric spaced segments of water-insoluble hydroxyethylcellulose which bind the fibers in the fiber layer to produce an intermittently bonded nonwoven fabric which is practically non-pilling in washing and laundering.

2. A method of making an intermittently bonded nonwoven fabric which is practically non-pilling in washing and laundering, which comprises: forming a layer of overlapping, intersecting fibers; printing the layer in a predetermined pattern of spaced segments penetrating substantially through the thickness of said layer from one surface thereof to the other surface with an alkaline solution of hydroxyethyl cellulose having a viscosity of from about 600 to about 1500 centipoises and a caustic content of from about 6% to about 9½%, said hydroxyethyl cellulose having an ethylene oxide content of from about 2% to about 5% by weight, said ethylene oxide being substantially uniformly distributed throughout the cellulose molecule, and said hydroxyethyl cellulose having a degree of polymerization of from about 250 to about 1000 and being water-insoluble; and coagulating

said hydroxyethyl cellulose solution while the same is in the aforesaid printed form to deposit on and in the fabric spaced segments of water-insoluble hydroxyethylcellulose which bind the fibers in the fiber layer to produce an intermittently bonded nonwoven fabric which is practically non-pilling in washing and laundering.

3. A method of making an intermittently bonded nonwoven fabric which is practically non-pilling in washing and laundering, which comprises: forming a layer of overlapping, intersecting fibers; printing the layer in a predetermined pattern of spaced segments penetrating substantially through the thickness of said layer from one surface thereof to the other surface with an alkaline solution of hydroxyethyl cellulose having a viscosity of from about 450 to about 2000 centipoises and a caustic content of from about 7% to about 9½%, said hydroxyethyl cellulose having an ethylene oxide content of from about 3½% to about 4½% by weight, said ethylene oxide being substantially uniformly distributed throughout the cellulose molecule, and said hydroxyethylcellulose having a degree of polymerization of from about 270 to about 600 and being water-insoluble; and coagulating said hydroxyethyl cellulose solution while the same is in the aforesaid printed form to deposit on and in the fabric spaced segments of water-insoluble hydroxyethylcellulose which bind the fibers in the fiber layer to produce an intermittently bonded nonwoven fabric which is practically non-pilling in washing and laundering.

4. An intermittently bonded nonwoven fabric which is practically non-pilling in washing and laundering which comprises a layer of overlapping, intersecting fibers and from about 1% to about 10% by weight, based on the weight of the layer, of a water-resistant hydroxyethyl cellulose binder distributed thereon in a predetermined pattern comprising a multiplicity of spaced, discrete binder segments extending substantially completely through the thickness of said layer from one surface

thereof to the other surface and covering from about 7% to about 50% of the total surface of said layer, said hydroxyethyl cellulose being extremely uniformly etherified along its chain length and having a degree of etherification corresponding to an ethylene oxide content of from about 2% by weight to about 5% by weight and a degree of polymerization of from about 250 to about 1000.

5. An intermittently bonded nonwoven fabric which is practically non-pilling in washing and laundering which comprises a layer of overlapping, intersecting fibers and from about 1% to about 10% by weight, based on the weight of the layer, of a water-resistant hydroxyethyl cellulose binder distributed thereon in a predetermined pattern comprising a multiplicity of spaced, discrete binder segments extending substantially completely through the thickness of said layer from one surface thereof to the other surface and covering from about 7% to about 50% of the total surface of said layer, said hydroxyethyl cellulose being extremely uniformly etherified along its chain length and having a degree of etherification corresponding to an ethylene oxide content of from about 3½% by weight to about 4½% by weight and a degree of polymerization of from about 270 to about 600.

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