United States Patent [19]

Tunc

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[54] **WATER DISPERSIBLE NONWOVEN FABRIC**

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[52] **U.S. Cl.** .... **128/284,** 117/143 A, 128/287, 128/290 W, 161/169, 260/224

[51] **Int. Cl.** **A41b 13/02,** A61f 13/16

[58] **Field of Search** .... 128/156, 284, 286, 287, 128/290, 296; 117/140, 143 A; 161/151, 169; 260/224

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Primary Examiner—Charles F. Rosenbaum

[57] **ABSTRACT**

A water dispersible nonwoven fabric comprising one or more layers of overlapping, intersecting fibers and from about four percent to about thirty-five percent by weight of an alkali cellulose ether sulfate resin binder, said nonwoven fabric having good tensile strength and abrasion resistance in the presence of body fluids such as urine, blood, and menstrual fluid. The nonwoven fabrics may be incorporated in body fluid absorbent products such as sanitary napkins, diapers, surgical dressings, and the like.

25 Claims, 5 Drawing Figures

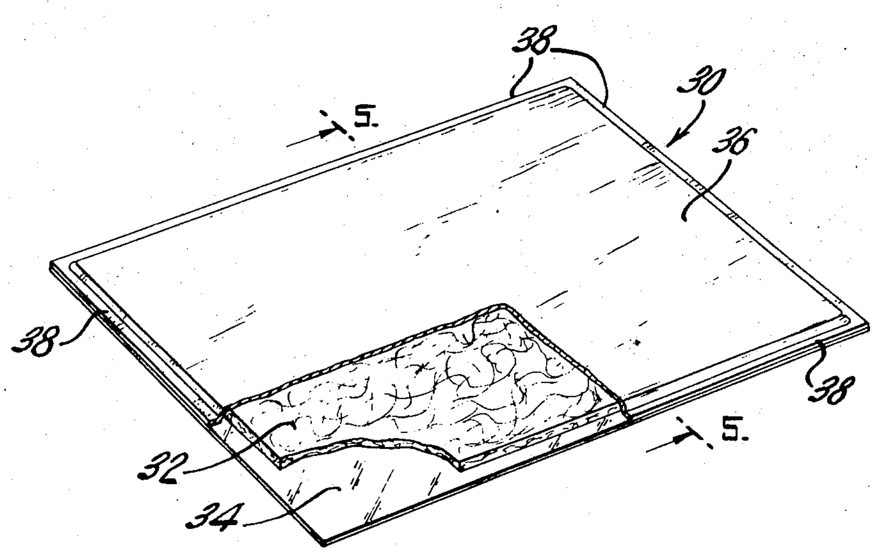


Fig. 1.

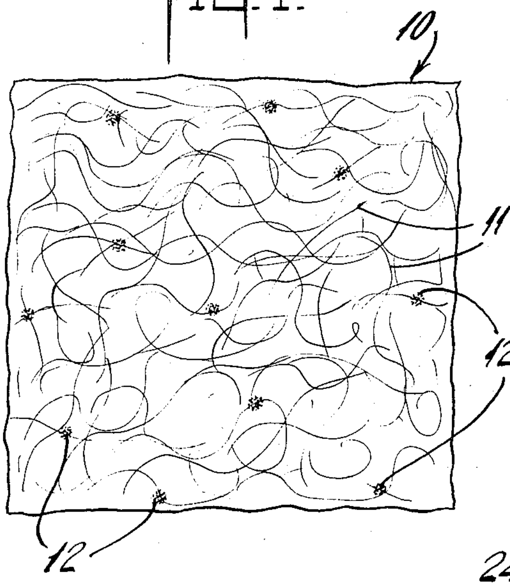


Fig. 3.

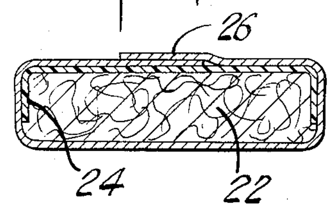


Fig. 2.

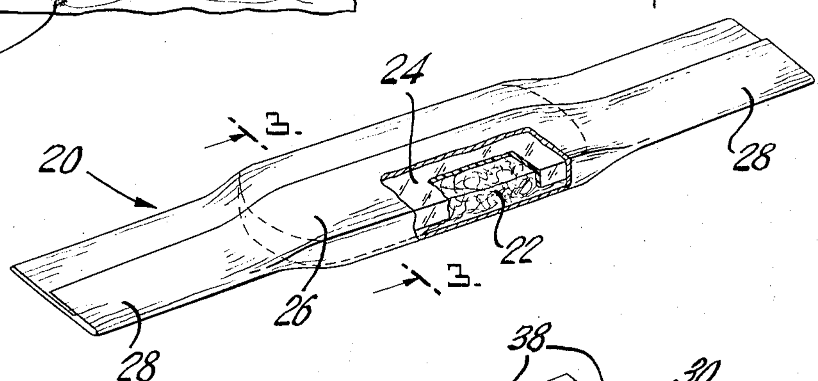
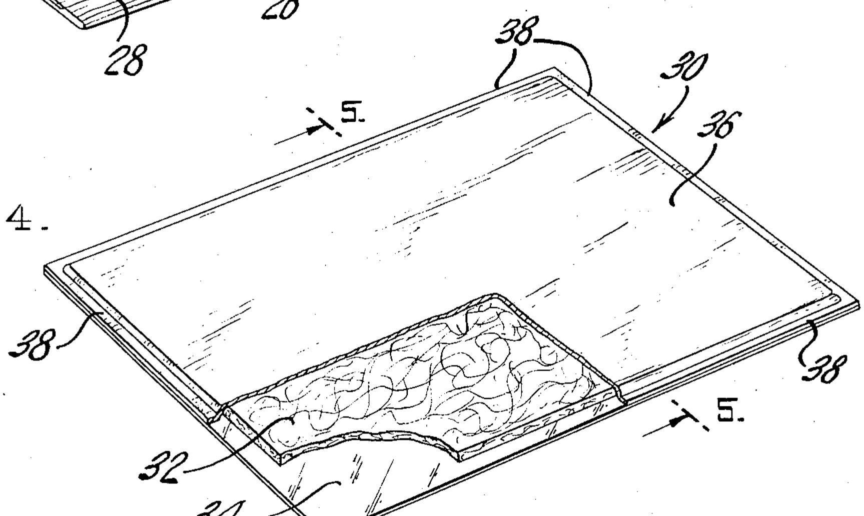


Fig. 4.



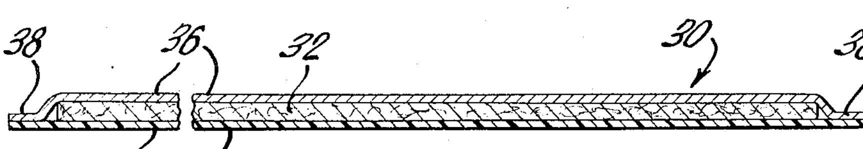


Fig. 5.

WATER DISPERSIBLE NONWOVEN FABRIC

This invention relates to new nonwoven fabrics which are readily dispersible in water and are flushable. More particularly, this invention relates to nonwoven fabrics which, in addition to having the above-mentioned desirable characteristics, exhibit satisfactory tensile strength when they are contacted with body fluids.

Nonwoven fabrics are widely used as components of such disposable goods as sanitary napkins, diapers, bandages, and the like. Such fabrics, if they are to function effectively, must maintain their structural integrity, as well as exhibit satisfactory tensile strength, when they are wet or damp with the various body fluids, for example, blood, menstrual fluid and urine, with which they come into contact during use. It has been recognized that if such nonwoven fabrics, while retaining their strength in body fluids, were to lose substantially all their tensile strength when exposed to water and become readily dispersible therein, disposal problems would be substantially eliminated since the fabrics could be easily and conveniently flushed away in a water closet.

Unfortunately, in an attempt to provide nonwoven fabrics having certain in-use characteristics, prior methods have rendered the fabric nondispersible in water. For example, nonwovens have been bonded with body fluid-insoluble resins which impart in-use strength. Generally, however, such resins have also been water insoluble as well and have impeded flushing of the fabric. Therefore, less desirable methods of disposal such as incineration or dumping must be employed.

SUMMARY OF INVENTION

I have now discovered a bonded nonwoven fabric which, in addition to having good strength when dry, and satisfactory strength and abrasion resistance in the presence of most body fluids, such as urine, blood, menstrual fluid and the like, is easily dispersible in water and hence is flushable in home water closets and capable of disposal in standard sewer systems or septic systems. In this connection when an article, for example, a barrier means, an absorbent core, a nonwoven fabric or the like is referred to herein as being flushable, it is meant that that article may be deposited in, and flushed through, a water closet without any undue clogging of the water closet or its auxiliary piping. When such an article is referred to herein as being water dispersible, it is meant that that article, when placed in water, loses its integrity and is flushable.

The improved nonwoven fabric of this invention comprises one or more layers of overlapping, intersecting fibers and from about four percent to about **35** percent by weight of the fabric of binder. The binder comprises an alkali cellulose ether sulfate resin, such as, for example, an alkali alkyl cellulose sulfate, an alkali hydroxyalkyl cellulose sulfate or an alkali hydroxyalkyl alkyl cellulose sulfate wherein each of the alkyl and hydroxyalkyl groups contains not more than four carbon atoms.

Examples of the alkali cellulose ether sulfates which may be used as binders for the nonwoven fabrics herein described are such alkali alkyl cellulose sulfates as sodium methylcellulose sulfate, potassium ethyl cellulose sulfate, sodium propyl cellulose sulfate and potassium butyl cellulose sulfate; such alkali hydroxyalkyl cellulose sulfates as sodium hydroxyethyl cellulose sulfate, sodium hydroxypropyl cellulose sulfate and sodium hydroxybutyl cellulose sulfate; and such alkali hydroxyalkyl alkyl cellulose sulfates as sodium hydroxypropyl methyl cellulose sulfate, potassium hydroxyethyl ethyl cellulose sulfate and sodium hydroxyethyl propyl cellulose sulfate.

The fabrics prepared in accordance with this invention have good dry tensile strength depending upon, among other things, the amount of binder applied to the fabric and the manner in which it is applied. They are abrasion resistant and retain a significant part of their dry tensile strength in solutions containing about 0.8 percent or more by weight of sodium chloride, and yet are readily dispersible in water. Because of this latter property, the nonwoven fabrics of this invention are uniquely suited for use in products to be contacted with such body fluids as blood, menstrual fluid, urine and the like. These fluids, in general, exhibit properties which, with respect to the binder, are analogous to aqueous salt solutions having a salt content which varies from about 0.8 to about 1.5 percent by weight of sodium chloride. On the other hand tap water normally supplied to water closets and the like generally has an extremely low concentration of salt, for example, less than 250 parts per million of chloride ion. It has been discovered that the nonwoven fabrics made as described herein maintain their integrity for a substantial period of time in solutions having a salt concentration exhibiting the properties of body fluids whereas they display a far lower resistance to dispersion in tap water. This unique property is a function of the degree of sulfate substitution (hereinafter, "D.S.") which expresses the average number of sulfate groups per anhydroglucose unit of the cellulosic ether. The nonwoven fabric bonded by the aforementioned cellulosic resins will exhibit increasing dispersibility in water and decreasing strength in salt solutions as the D.S. of the cellulosic resin is increased. It has been discovered that a nonwoven fabric bonded by resins having a D.S. varying from about 0.10 to about 0.30 is useful in products designed to be contacted by various body fluids. In another aspect of this invention, the nonwoven fabrics are incorporated into such body fluid absorbent products as sanitary napkins, diapers, surgical dressings and the like. These products generally include an absorbent core, comprising one or more layers of an absorbent fibrous material. The core may also comprise one or more layers of a fluid-pervious element, such as tissue, gauze, plastic netting, etc. These are generally useful as wrapping materials to hold the components of the core together. Additionally, the core may comprise a fluid-impervious element or barrier means to preclude the passage of fluid through the core and on to its outer surfaces. In accordance with this aspect of the instant invention, a body fluid absorbent product is provided having a nonwoven fabric in contact with an absorbent core, the nonwoven fabric comprising a layer of overlapping intersecting fibers from about 4 to about 35 percent by weight of fabric of an alkali cellulose ether sulfate resin binder having an average of from about 0.10 to about 0.30 sulfate groups per anhydroglucose unit.

The invention will be more clearly understood by reference to the attached drawings taken together with the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a bonded nonwoven fabric in accordance with the present invention;

FIG. 2 is a perspective view of a sanitary napkin embodying this invention with parts broken away to show the interior construction thereof;

FIG. 3 is a cross-sectional view taken approximately along lines 3—3 of FIG. 2;

FIG. 4 is a perspective view of a disposable diaper embodying this invention with parts broken away to show the interior construction thereof; and

FIG. 5 is a cross-sectional view taken approximately along lines 5—5 of FIG. 4.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. 1 and 2, there is shown a water dispersible nonwoven fabric 10. The fabric comprises a layer of overlapping, intersecting fibers 11 having substantially uniformly distributed therein an alkali cellulose ether sulfate binder 12 as hereinafter described.

The alkali cellulose ether sulfates used as the binder for the nonwoven fabrics of this invention may be produced by first forming the ether derivatives of cellulose and then sulfating with a suitable sulfating agent. The ether derivatives are generally prepared by reacting a purified form of cellulose with either an alkyl halide, and alkylene oxide or both to form either the alkyl ether, the hydroxyalkyl ether or the hydroxyalkylalkyl ether, respectively. Unsulfated cellulose ethers are presently available as, for example, the methylcellulose and hydroxypropyl methylcellulose ethers sold under the trandemark METHOCEL and the ethylcellulose ethers sold under the trademark ETHOCEL, all available from the Dow Chemical Company, Inc. of Midland, Michigan. Hydroxyethyl cellulose ethers are available from Hercules, Incorporated, and Union Carbide Corporation under the trademarks NATROSOL and CELLOSIZE, respectively.

Table A below illustrates properties of typical ethers suitable for sulfating and use in accordance with this invention:

TABLE A

Ethyl cellulose	4–5,000 cps[1]	2.21–2.58[3]
Methyl cellulose	8–10,000 cps[2]	1.64–1.92[3]
Hydroxypropyl Methyl cellulose	50–60,000 cps[2]	19–33% by weight methyl 4–12% by weight propylene glycol ether

[1]5% ethyl cellulose in 80/20 (wt./wt.) Toluene/Ethanol at 25°C.
[2]2% (wt.) Aqueous Solution at 20°C.
[3]The average degree of substitution of alkyl groups per anhydroglucose unit.

The ethers may be sulfated in accordance with a process described in U. S. Patent application Ser. No. 232,371, filed Mar. 7, 1972 whereby an alkali sulfating agent is prepared by reacting acetic anhydride with sulfuric acid and an alkali sulfate, all in an acetic acid solution, to form alkali acetyl sulfate. The alkali acetyl sulfate is then reacted with the cellulose ether to yield the alkali cellulose ether sulfate resin.

In accordance with this invention, it has been discovered that by modifying the D.S. of the cellulosic resin binder, the salt resistance and water dispersibility of the bonded nonwoven fabric can be modified to provide fabrics which will function effectively when contacted by various body fluids and which may be flushed away in a water closet. Specifically, by lowering the degree of sulfation of the cellulosic resins, the fabrics of this invention become more resistant to salt solutions in that they retain their integrity after being subjected to these solutions for long periods of time and in that they exhibit higher tensile strengths when subjected to a given salt concentration for a given period of time. In general, if the D.S. of the cellulosic resin is maintained at below about 0.3, an adequately salt resistant nonwoven fabric results. Preferably, the D. S. should be maintained at below about 0.25. While the resistance of the nonwoven fabrics to salt solutions having a salt concentration exhibiting the properties of body fluids increases greatly with decreasing D.S., the ability of the fabrics to disperse readily in water is maintained until extremely low D.S. values are reached. Adequate water dispersibility is achieved when the D.S. of the cellulosic resin is maintained at a value of at least about 0.10. Preferably, the D. S. should be not less than about 0.15.

The aforementioned alkali cellulose ether sulfate resins are used to bond a base layer of fibers to provide the nonwoven fabric of this invention. Suitable base layers comprise most of the well-known fibers, the choice depending upon, for example, fiber cost and the intended end use of the finished fabric. For instance, the base layer may include natural fibers such as cotton, linen, jute, hemp, cotton linters, wool, wood pulp, etc. Similarly, regenerated cellulosic fibers such as viscose rayon and cuprammonium rayon, modified cellulosic fibers, such as cellulose acetate, or synthetic fibers such as those derived from polyvinyl alcohol, polyesters, polyamides, polyacrylics, etc., alone or in combination with one another, may likewise be used. Natural fibers may be blended with regenerated, modified, and/or synthetic fibers if so desired.

The length of the fiber is important in producing the fabrics of the present invention. The minimum length of the fibers depends on the method selected for forming the base layer. For example, where the base layer is formed by carding, the length of the fiber should usually be a minimum of ½ inch in order to insure uniformity. Where the base layer is formed by air deposition or water deposition techniques, the minimum fiber length may be about 0.05 inch. It has been found that when a substantial quantity of fibers having a length greater than about 2 inches is placed in the fabric, though the fibers will disperse and separate in water, their length tends to form "ropes" of fibers which are undesirable when flushing in home water closets. It is preferred that the fiber length be 1½ inches or less so that the fibers will not "rope" when they are flushed through a toilet.

The base layers suitable for conversion into the fabric of the present invention may be formed by carding, garnetting, air deposition, water deposition, or any of the other various techniques known in the art, The fibers in the layer may be oriented predominantly in one direction as in a card web or a card web laminate or they may be randomly oriented as in a layer formed by air deposition techniques. For sanitary napkin coverings, disposable diaper facings and similar uses where the fabric is to be flushable, the web is fairly thin and should weigh between 150 to 400 grains per square yard. Where the fabric must possess a substantial amount of strength, uniform fiber distribution is important so as to avoid weak spots in the final nonwoven fabric. Uniform base layers may be produced by carding in which case it is advantageous to use fibers which have good carding characteristics and can be blended into a uniform carded web with facility. Fibers of viscose rayon and cotton are both satisfactory in this respect.

The amount of alkali cellulose ether sulfate binder distributed in the base layer should be from about 4 to 35 percent by weight of the final nonwoven fabric. If less than about 4 percent of the cellulosic binder is employed, the fabric does not have sufficient strength and abrasion resistance to be of any utility. If more than about 35 percent of the cellulosic binder is employed, the fabric may lose desirable properties such as absorbency and softness.

It is preferred that the amount of alkali cellulose ether sulfate binder be between about 4 to 20 percent by weight of the final nonwoven fabric in order to ensure optimum water dispersibility.

The binder may be distributed in the base layer by printing, spraying, impregnating or by any other technique wherein the amount of binder may be metered and the binder can be distributed uniformly within the base layer. The binder may be distributed throughout the entire base layer or it may be distributed therein in a multiplicity of small closely spaced areas. The binder may be distributed in lines running across, or at an angle to, the width of the web or in separate small shaped areas having circular, angular, square, or triangular configurations. It is preferred that when the binder is applied to the fibrous layer there be left unbonded areas in the layer. These unbonded areas of fibers readily absorb water which attacks the binder areas and makes the fabric dispersible in shorter periods of time.

For ease of application to the base fibrous layer, the cellulosic resin binder may be dissolved in water, methanol, ethanol, or in suitable mixtures thereof, to provide solutions containing up to about 30 percent by weight of binder solids. Plasticizers, such as glycerol, polyethylene glycol, and castor oil, may be added to the solution of the cellulosic resin, the amount of such plasticizers varying according to the softness required in the final fabric. Perfumes, coloring agents, antifoams, bactericides, surface active agents, thickening agents and similar additives may be incorporated into the solution of the cellulosic resin binder if so desired. Other binding agents such as polyvinyl alcohol or aqueous dispersions of, for example, polyvinyl chloride, polyvinyl acetate, polyacrylates, polymethacrylates, copolymers of acrylates and methacrylates, copolymers of vinyl acetate with acrylates and/or methacrylates and copolymers of acrylates and/or methacrylates with vinyl chloride may be added to the cellulosic binder solution in order to obtain fabrics having various desired properties.

Referring now to FIGS. 2 and 3 of the drawing, illustrated therein is an embodiment of the water dispersible non-woven fabric of this invention as used with a sanitary napkin **20**.

Napkin **20** comprises an absorbent core which is contacted by a fluid-pervious cover **26** comprising the bonded nonwoven fabric of this invention. The absorbent core comprises a pad **22** of absorbent fibrous material such as comminuted wood pulp fibers, cotton linters, rayon fibers, cotton staple, bleached sulfite linters, other cellulosic or modified cellulosic fibers and the like. The absorbent core further comprises a fluid-impervious element or barrier means **24** which, for example, may be a thin polyethylene sheet or any other suitable material. As best seen in FIG. **3**, barrier means **24** overlies the sides and the bottom surface of absorbent pad **22** (the bottom surface being that portion worn away from the body). Fluid-pervious cover **26** surrounds absorbent pad **22** and barrier means **24** with the lateral edges thereof overlapped and secured on the bottom surface of napkin **20**. Cover **26** is extended beyond the ends of the absorbent core to form the usual attachment tabs **28**. While FIGS. **2** and **3** illustrate a tabbed napkin, it will be understood by one skilled in the art that the advantages accruing to the use of the nonwoven fabrics of this invention are equally applicable to a tabless product, e.g., one where tabs are not used as attachment means and other attachment means such as, for example, adhesive means, are used. It will also be understood that the absorbent core may comprise, in addition to the absorbent pad and barrier means, a fluid-pervious element such as gauze, tissue, plastic netting and the like if increased strength and/or dimensional stability are desired. It will be further understood that the fluid pervious cover of this invention need not completely surround the absorbent pad as illustrated in FIGS. **2** and **3**. For example one could provide a fluid pervious cover, the edges of which are adhered to the edges of the barrier means; in such a case, the barrier means and fluid pervious cover would cooperate to form an enclosure for the pad of absorbent fibrous material.

The nonwoven fabric of this invention is uniquely suited to serve as a fluid-pervious covering in a sanitary napkin, such as shown in FIGS. **2** and **3**, because is is resistant to abrasion and exhibits satisfactory tensile strength when it has been dampened or wetted with menstrual fluid, which has a salt content of about 0.8 to about 1.5 percent by weight. The fabics of this invention are resistant to solutions containing more than about 0.8 percent salt, and notwithstanding such salt resistance, the fabrics are completely dispersible when introduced into water or into salt solutions whose salt content is less than about 0.8 percent by weight. It will be apparent that, by employing a water-dispersible material for the barrier means and a water-dispersible absorbent pad, the sanitary napkin of FIGS. **2** and **3** may be conveniently and completely disposed of by flushing through a water closet.

Alternatively, the illustrated napkin may be provided with a non-water dispersible barrier means and a water-dispersible absorbent pad. In that case, fluid-pervious covering **26** is first removed and the barrier means is separated from the pad; the pad and covering can then be dropped into a water closet for disposal. In either case, the unique nonwoven fabric of this invention will be completely dispersed in a water closet under the swirling action of the water supplied thereto and will not impair the normal operation of the water closet and associated plumbing. Referring to FIGS. **4** and **5** of the drawing, there is illustrated therein another embodiment of the water dispersible nonwoven fabric of this invention as used with a disposable diaper **30**.

Diaper **30** comprises an absorbent core and a fluid-pervious facing **36** comprising the nonwoven fabric of this invention. The absorbent core comprises an absorbent layer **32** of fibrous material such as comminuted wood pulp fibers, cotton linters, rayon fibers, cotton staple, bleached sulfite linters, other cellulosic or modified cellulosic fibers, and the like. The absorbent core further comprises a body fluid-impervious element or barrier means **34** which overlies the bottom surface of absorbent layer **32.** Barrier means **34** may comprise for example, a thin sheet of polyethylene or other suitable material. Where barrier means **34** is not water dispersible, it is convenient that it be easily removed from the remainder of the diaper so as to minimize disposal problems. Fluid-pervious facing **36** overlies the top surface of absorbent layer **32.** In the embodiment illustrated in FIGS. **4** and **5,** it will be observed that barrier means **34** and fluid-pervious facing **36** are substantially coextensive and are joined together at their peripheries **38** by methods well known in the art such bonding, adhesive bonding stitching, and heat sealing techniques.

While FIG. **4** illustrates a disposable diaper having a particular construction, it will be recognized by those skilled in the art that the advantages accruing to the use of the nonwoven fabrics of this invention are equally applicable to disposable diapers having other, widely varying constructions. The absorbent core is not limited to the structure illustrated, but may include a fluid-pervious element, such as gauze, tissue, plastic netting and the like, if it is desired to increase strength and/or structural integrity.

The nonwoven fabric of this invention is uniquely suited to serve as the fluid-pervious facing of a disposable diaper as shown in FIG. **4** because it is resistant to abrasion and exhibits acceptable tensile strength when dampened or wetted with urine. Urine, as in the case of menstrual fluid, has a salt content of about 0.8 to about 1.5 percent by weight. As already indicated, the nonwoven fabrics herein are resistant to solutions containing about 0.8 percent or more by weight of sodium chloride. It will be apparent that by employing a water-dispersible material for the barrier means and a water-dispersible, absorbent layer, the diaper of FIG. **4** can be safely and conveniently disposed of by flushing through a water closet. When the diaper of FIG. **4** has been provided with a barrier sheet that is not water dispersible, but has a water-dispersible, absorbent layer, then the layer and the facing may be safely flushed after they have been separated from the barrier means.

Those skilled in the art will readily understand that the water-dispersible nonwoven fabric of this invention may be advantageously employed in the preparation of a wide variety of absorbent products designed to be contacted with body fluids. Many such absorbent products need only comprise a core of absorbent material in combination with said nonwoven fabric. For example, an absorbent surgical dressing could be made comprising a relatively thin, rectangular layer of absorbent material with the nonwoven fabric overlying one or more sides thereof. Similarly, as in the case of a tampon, the nonwoven fabric could overlie a cylindrical core of absorbent material. Alternatively, the core of absorbent material could be in the form of a sphere, a cube, a disc, or other desirable geometrical configuration.

In order to better illustrate the invention, the following examples are given:

EXAMPLE I

Sodium ethyl cellulose sulfate is prepared as follows: A sulfating agent, sodium acetyl sulfate, is prepared by combining the following ingredients:

	Parts by Weight
Sodium Sulfate	8.1
Acetic Anhydrid (98% pure)	42.8
Glacial Acetic Acid	13.8
Sulfuric Acid (95% pure)	5.3

The sodium sulfate is first added to a mixture of the acetic anhydride and acetic acid at room temperature, the sulfuric acid then being added at a rate such that the temperature of the mixture does not exceed 54.4°C. The resulting solution is neutralized by adding small increments of sodium sulfate and is then cooled to 4.4°C. and filtered.

ETHOCEL Std., a trademark of the Dow Chemical Company for ethylcellulose ether, is dissolved in acetic acid in a proportion of 45.4 parts by weight of resin in 115 parts of acetic acid. ETHOCEL Std. has a degree of ethyl substitution of 2.46 to 2.58 and a 90 percent by weight solution of the resin dissolved in a mixture of toluene and ethyl alcohol in the proportions of 80 to 20 parts by weight, respectively, and measured at 25°C., has a viscosity of 40 to 50 cps. The resin is dissolved in the acetic acid by mixing in a jacketed sigma blade mixer, for about 30 minutes at a jacket temperature of 38°C. The jacket temperature is then dropped to 15°C. and held at that temperature until the reaction mixture has cooled at 21°C.

The sulfating solution is then added incrementally over a period of 20 minutes, taking care not to exceed a reaction temperature of 32°C. The resulting reacted mixture is then added to an aqueous, ten percent by weight, sodium hydroxide solution in a ratio of one part by weight of reacted mixture to ten parts by weight of the sodium hydroxide solution. This mixture is stirred vigorously and the pH is maintained at approximately ten by the addition of requisite quantities of additional ten percent sodium hydroxide solution.

The resulting precipitated resin is separated from its mother liquor by filtering in a Buchner funnel. The precipitate is then dried at a temperature of 50°C. in a forced-air oven and ground in a Wiley mill, to a particle size of from one to two millimeters in diameter. The ground particles are washed by combining them with ten times their weight of boiling water and stirring vigorously while adjusting the pH to a value of 5.5 with the addition of ten percent by weight of hydrochloric acid solution. The precipitate resulting from this washing step is filtered, dried and ground in the manner described above. The washing step and the filtering, drying, and grinding are repeated once again.

The resulting resin has a degree of sulfate substitution of 0.43.

EXAMPLE II

With appropriate changes in the amount of sulfating agent employed, the procedure of Example I was followed to prepare a series of sodium ethyl cellulose sulfate resins having degrees of sulfate substitution equal to, respectively, 0.33, 0.28, and 0.24. Binder solutions wre then prepared by dissolving these resins in water to give a solution containing 2½ percent by weight resin solids. A fibrous web of 1 9/16 inch, 1.5 denier, dull viscose rayon weighing about 1½ ounces per square yard was formed by an air deposition technique using a Randowebber (commercially available from Curlator Corporation). Nonwoven fabrics were then prepared by saturating swatches of the fibrous web with the above described binder solutions and drying at 150°F for 90 minutes. The nonwoven fabrics so prepared comprised about 23 percent by weight of binder solids.

The nonwoven fabrics identified as A, B, C, respectively, were tested for tensile strength after immersion in water, and after immersion in aqueous solutions containing, respectively, 0.9 percent and 1.6 percent sodium chloride.

The following procedure was used for the determination of tensile strengths in tap water and in aqueous salt solutions. The fabric to be tested was equilibrated for 24 hours at 72°F. and 65 percent relative humidity. Fabric grain weight was determined in the usual way. Three inch by one inch strips were cut from the fabric, immersed in the desired test solution, removed, drained for 15 seconds, and gently blotted between paper toweling. The test strips were then tested on an Instron tester using a jaw spacing of 2 inches and a pull speed of 2 inches per minute. Raw test data was converted to tensile strength units of pounds per gram of fabric (hereinafter, "Lbs./Gm.").

The results of the tensile strength tests, which are set forth in Table II, show generally that the tensile strength of a given nonwoven fabric increases as the salt content of the solution in which the fabric is immersed is increased. It is also noted that as the degree of sulfate substitution in the cellulosic binder decreases, tensile strength after immersion in water remains at the same general level while tensile strength after immersion in each of the salt solutions increases.

Y, containing 7 percent solids. Nonwoven fabric D was then made by using an engraved roll to print bond a sample of the above mentioned fibrous web with binder solution X and then drying the printed web over steam heated cans held at about 270°F. Nonwoven fabric E was prepared in the same way using binder solution Y.

The pattern engraved on the print roll comprised 6 horizontal wavy lines per inch, each engraving being 0.024 inch wide and 0.010 inch in depth. The nonwoven fabrics so prepared comprised about 82 percent by weight of viscose rayon and about 18 percent by weight of resin binder.

The fabrics were tested, after equilibration for 24 hours at 72°F and 65 percent relative humidity, for tensile strength, pinning strength, and flexural resistance.

Tensile strength was determined by pulling 7 inch long by 3 inch wide samples on a Scott IP-IV incline plane tester having a jaw spacing of 3 inches. Results of the tensile strength tests were reported in pounds per three inch width of fabric.

Pinning strength was determined on a modified Scott IP-IV incline plane tester wherein each of the usual jaws carried a safety pin for grasping the sample to be tested. Fabric strips measuring 7 inches by 3 inches were used for this test. The space between the safety pins was 3 inches. Results of pinning strength tests were reported in pounds.

Flexural resistance tests, which measure the softness of the nonwoven fabric, were run on a modified Thwing-Albert Handle-O-Meter. Test results are reported in arbitrary units--the higher the number, the softer the fabric.

TABLE II

Nonwoven fabric	Resin, degree of substitution	Wet tensile, water: Machine direction	Wet tensile, water: Cross direction	Wet tensile, 0.9% aq. NaCl: Machine direction	Wet tensile, 0.9% aq. NaCl: Cross direction	Wet tensile, 1.6% aq. NaCl: Machine direction	Wet tensile, 1.6% aq. NaCl: Cross direction
A	0.33	0.34	0.63	4.0	5.1	6.1	8.7
B	0.28	0.35	0.32	4.8	5.0	6.4	7.6
C	0.24	0.41	0.40	6.2	10.5	8.8	16.1

EXAMPLE III

A fibrous web was prepared from 1⅛ inch, 1.5 denier, extra dull viscose rayon by a standard carding operation. The web weighed about 280 grains per square yard. Two sodium ethyl cellulose sulfate resins were prepared by the method of Example I, except that different amounts of the sulfating agent were employed in order to vary the degree of sulfate substitution. The resins had degrees of sulfate substitution equal to 0.19 and 0.23. The resin having a degree of sulfate substitution equal to 0.19 was dissolved in 2:1 (weight) methanol/water mixture to give a binder solution, designated X, containing 11 percent solids. The resin having a degree of sulfate substitution equal to 0.23 was dissolved in methanol to give a binder solution, designated

For purposes of comparison, a water dispersible nonwoven fabric made according to the Example set forth in Column 5 of U.S. Pat. No. 3,554,788 was used as a control. Test results for the experimental fabrics and the control are given in Table III. The results show that fabrics D and E, prepared with sodium ethyl cellulose sulfate having degrees of sulfate substitution of 0.19 and 0.23, respectively, are suitable for use as fluid pervious facings in sanitary napkins having tabs.

TABLE III

Fabric	Degree of substitution, resin	Fabric weight, grains/yd.[2]	Dry tensile strength, lbs./3" width: Machine direction	Dry tensile strength, lbs./3" width: Cross direction	Pinning strength, pounds	Flexural resistance
D	0.19	355	10.1	1.73	2.9	81
E	0.23	331	17.2	1.25	2.5	71
Control [1]		260	10.0	0.95	(*)	65

[1] U.S. 3,544,788.

*This test not run on control fabric. Experience has shown that a pinning strength of 2.5 is desirable where the nonwoven fabric is to be used as the fluid pervious facing for a commercially acceptable tabbed sanitary napkin.

EXAMPLE IV

Sanitary napkins were prepared using the construction of a commercially-available flushable napkin sold by Personal Products Company, Milltown, New Jersey, a corporation of the state of New Jersey, as MODESS (trademark of Johnson & Johnson) flushable feminine napkins. The construction of the MODESS flushable napkin is generally similar to that illustrated in FIGS. 2 and 3. The nonwoven fabrics of Example III, including the control fabric described therein, were used in place of the nonwoven fabric normally provided as the covering material. Fifteen napkins were prepared for each of the fabrics to be tested. The sanitary napkins so made were then tested for flushability by flushing them through a testing system designed for such purposes. The testing system comprises an American Standard toilet fitted with 3 inch (I.D.) copper piping, approximately 11–12 feet long. This pipe is connected to the toilet by way of an elbow and a suitable length of vertically placed piping. At the opposite end of the pipe, and at right angles thereto, there is placed an exit pipe about 20 inches long. There is a tubular wire mesh screen, about 18 inches long, concentrically placed within the exit pipe, the screen carrying several rows of barbs to simulate any internal rough surfaces in a sewage system. The test is conducted by dropping the sanitary napkin into the toilet bowl, waiting 15 seconds, and then flushing. After each napkin is flushed, the screen is removed and the residue thereon is visually rated by comparison with a set of standard photographs. A flushability rating of excellent (1), good (2), fair (3), or poor (4) is then assigned to the napkin under test.

Table IV shows the average flushability rating of 15 runs for each of the test fabrics and the control. The napkins covered with the experimental fabrics were found to have better flushing characteristics than the napkin covered with the control fabric. All napkins were considered to be satisfactory for safe flushing through an average plumbing system.

TABLE IV

Fabric	Resin-Degree of Substitution	Flushability Rating (Average of 15 runs)
D	0.19	1.9 (Good)
E	0.23	3.0 (Fair)
Control (U.S. Pat. No. 3,554,788)	(None)	3.5 (Fair-Poor)

EXAMPLE V

Fabrics D and E of Example III were tested for wet strength in the presence of water and aqueous salt solutions of varying concentrations. A sample of the fabric to be tested was placed across the mouth of a standard 400 ml. beaker and held in place with a rubber band. An area of the fabric approximately 2 inches in diameter was wetted with the desired test solution and a 54 gram steel ball was placed on the wetted area. The time in seconds required for the steel ball to break through the test fabric was recorded. The test was repeated six times for each fabric and the results for each fabric were averaged. In some instances testing was discontinued when a fabric under test did not fail within a certain period of time. Test results which are summarized in Table V show that Fabric D (D.S. = 0.19) and Fabric E (D.S. = 0.23) have very low strength when wet with water. For a given degree of sulfate substitution, fabric wet strength increases as the sodium chloride concentration in the test solution is increased. At any given concentration of salt in the test solution, fabric wet strength decreases as the degree of sulfate substitution increases.

Swatches of fabrics D and E, when placed in water and even slightly agitated, were observed to lose their integrity.

TABLE V

Wet strength of fabrics, test results reported in seconds

Percent NaCl in water	0	0.5	1.0	1.5	2.5	3.0	3.5	4.0
Fabric D	13.9	29.6	48.9	86.8	------	*600	*1,500	*1,800
Fabric E	6.5	10.3	18.6	30.5	------	228	*900	*1,500
Control** U.S. 3,544,788	6.0	------	------	9.0	12.0	------	14.0	------

*Test stopped at this point without fabric failure.

**Typical values when fabric of U.S. 3,544,788 is tested according to test outlined in Example V.

EXAMPLE VI

Fabric D of Example III was tested for abrasion resistance in the presence of menstrual fluid with the aid of a panel of 10 women. A quantity of MODESS flushable sanitary napkins, of the general type marketed by Personal Products Company of Milltown, New Jersey, under the designation MODESS flushable feminine napkins, was prepared using Fabric D of Example III in place of the cover provided on the commercial napkin. Each member of the test panel was provided with four such napkins for use during menstruation.

The average time of use was 4.75 hours; the average weight of fluid deposited on a napkin was 7.58 grams, which is considered heavy menstrual flow. Of the forty returned products, 92.5 percent showed slight to no abrasion while the remaining 7.5 percent showed moderate to heavy abrasion. It was concluded from this test that Fabric D had very good resistance to wet abrasion in the presence of menstrual fluid.

EXAMPLE VII

The procedure of Example VI was repeated except that Fabric E of Example III was used as the covering material for the napkins to be tested. Results of the panel test showed that Fabric E had good to excellent abrasion resistance in the presence of menstrual fluid.

EXAMPLE VIII

A disposable diaper is made as follows: An absorbent fibrous layer, measuring about 11 inches by about 15 inches, is prepared from comminuted wood pulp. The absorbent layer, which weighs about 20–25 grams, is then placed on a piece of 1 mil polyethylene film measuring about 12 inches by about 16 inches. This polyethylene film serves as a backing layer. A piece of nonwoven fabric D (Example III), also measuring about 12 inches by 16 inches, is placed over the absorbent layer in substantially coextensive relationship with the polyethylene film. This nonwoven fabric serves as the facing of the disposable diaper. Nonwoven fabric D and the polyethylene film are joined along their peripheries with any suitable adhesive means, for example, an aqueous based polyvinyl acetate adhesive, so that the absorbent layer is confined therebetween. Nonwoven fabric D has acceptable strength and good abrasion resistance in the presence of urine. After use, nonwoven fabric D and the absorbent layer are separated from the polyethylene film. The nonwoven fabric and the absorbent layer are then easily and safely disposed of by flushing in a toilet. It will be undersood that the above example is given for purposes of illustration only. Those skilled in the art will recognize that the polyethylene film could be replaced by other types of film or by any suitable woven or nonwoven fabric. The absorbent layer may comprise any of the other absorbent materials, for example, cellulose wadding, well known in the art. Additionally, it will be recognized that if the diaper comprises, in addition to the nonwoven fabric of this invention, a flushable absorbent layer and a flushable backing material, then the entire diaper may be disposed of by flushing in a toilet.

What is claimed is:

1. A water-dispersible nonwoven fabric comprising: a layer of overlapping, intersecting fibers, said fibers having a length not more than about two inches; and from about 4 to about 35 percent by weight of the fabric of an alkali cellulose ether sulfate resin binder distributed in said fabric, said resin binder having an average of from about 0.1 to about 0.3 sulfate groups per anhydroglucose unit.

2. A water-dispersible nonwoven fabric according to claim **1**, wherein said alkali cellulose ether sulfate resin has an average of from about 0.15 to about 0.25 sulfate groups per anhydroglucose unit.

3. A water-dispersible nonwoven fabric according to claim **1**, wherein the alkali cellulose ether sulfate resin is an alkali alkyl cellulose sulfate, said alkyl group having from one to four carbon atoms.

4. A water-dispersible nonwoven fabric according to claim **3**, wherein the alkali alkyl cellulose sulfate resin is sodium ethyl cellulose sulfate.

5. A water-dispersible nonwoven fabric according to claim **3**, wherein the alkali alkyl cellulose sulfate resin is sodium methyl cellulose sulfate.

6. A water-dispersible nonwoven fabric according to claim **1**, wherein the alkali cellulose ether sulfate resin is an alkali hydroxyalkyl cellulose sulfate, said hydroxyalkyl group having from one to four carbon atoms.

7. A water-dispersible nonwoven fabric according to claim **6** wherein the alkali hydroxyalkyl cellulose sulfate resin is sodium hydroxyethyl cellulose sulfate.

8. A water-dispersible nonwoven fabric according to claim **6**, wherein the alkali hydroxyalkyl cellulose sulfate resin is sodium hydroxypropyl cellulose sulfate.

9. A water-dispersible nonwoven fabric according to claim **1**, wherein the alkali cellulose ether sulfate resin is an alkali hydroxyalkyl alkyl sulfate, said hydroxyalkyl and said alkyl groups each having from one to four carbon atoms.

10. A water-dispersible nonwoven fabric according to claim **9**, wherein the alkali hydroxyalkyl alkyl cellulose sulfate is sodium hydroxypropyl methyl cellulose sulfate.

11. A water-dispersible nonwoven fabric according to claim **1** wherein, said fibers are viscose rayon fibers.

12. A water-dispersible nonwoven fabric according to claim **1** wherein the length of said fibers does not exceed about one and one half inches.

13. A water-dispersible nonwoven fabric according to claim **1**, wherein said resin binder is distributed in said fabric in a predetermined pattern.

14. A water-dispersible nonwoven fabric according to claim **1**, wherein said fibers are viscose rayon fibers having a length of from about one half inch to about one and one half inches and said resin binder is sodium ethyl cellulose sulfate.

15. A water-dispersible nonwoven fabric according to claim **1**, wherein there is from about 4 to about 20 percent of said resin binder by weight of the fabric.

16. A water-dispersible nonwoven fabric comprising: a layer of overlapping, intersecting textile fibers, said fibers being viscose rayon fibers from about one half inch to about one and one half inches in length; and from about 4 percent to about 20 percent of sodium ethyl cellulose sulfate distributed in said fabric, said sodium ethyl cellulose sulfate having an average of from about 0.15 to about 0.25 sulfate groups per anhydroglucose unit.

17. An absorbent product for contacting body fluids comprising: an absorbent core and a fluid-pervious, water-dispersible nonwoven fabric covering at least a portion of said absorbent core; said nonwoven fabric comprising a layer of overlapping, intersecting fibers, said fibers having a length not more than about two inches; and, distributed in said fabric, from about 4 to about 35 percent by weight of the fabric of an alkali cellulose ether sulfate resin binder, said resin binder having an average of from about 0.1 to about 0.3 sulfate groups per anhydroglucose unit.

18. An absorbent product according to claim **17** wherein said absorbent core includes a fluid-pervious element.

19. An absorbent product according to claim **18**, wherein the fluid-pervious element is tissue.

20. An absorbent product according to claim **18**, wherein the fluid-pervious element is gauze.

21. An absorbent product according to claim **18**, wherein the fluid-pervious element is a plastic netting.

22. An absorbent product according to claim **17**, wherein said absorbent core includes a fluid-impervious element.

23. An absorbent product according to claim **22**, wherein the fluid-impervious element comprises polyethylene.

24. An absorbent product according to claim **17**, wherein the absorbent core includes a fluid-pervious element and a fluid-impervious element.

25. An absorbent product according to claim **24**, wherein the fluid pervious element is tissue and the fluid-impervious material comprises polyethylene.

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