July 28, 1970 R. G. PARRISH 3,521,638

FABRICS HAVING WATER SOLUBLE DISCRETE AREAS AND METHOD OF MAKING

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FIG. 1

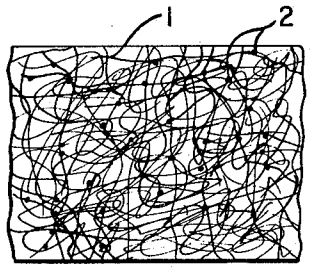


FIG. 2

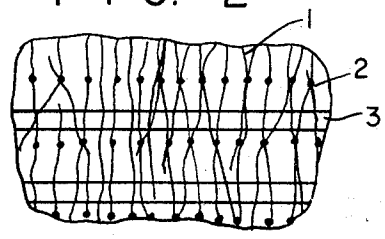


FIG. 3

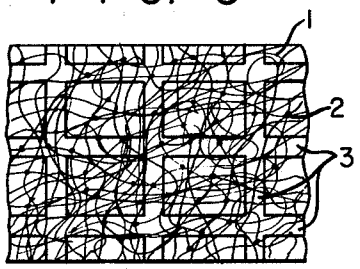
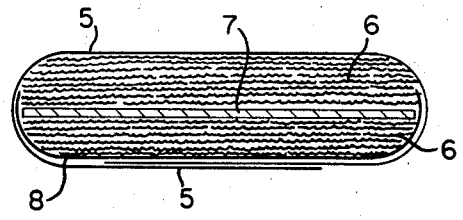


FIG. 4

FIG. 5



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FABRICS HAVING WATER SOLUBLE DISCRETE AREAS AND METHOD OF MAKING

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FIG. 6

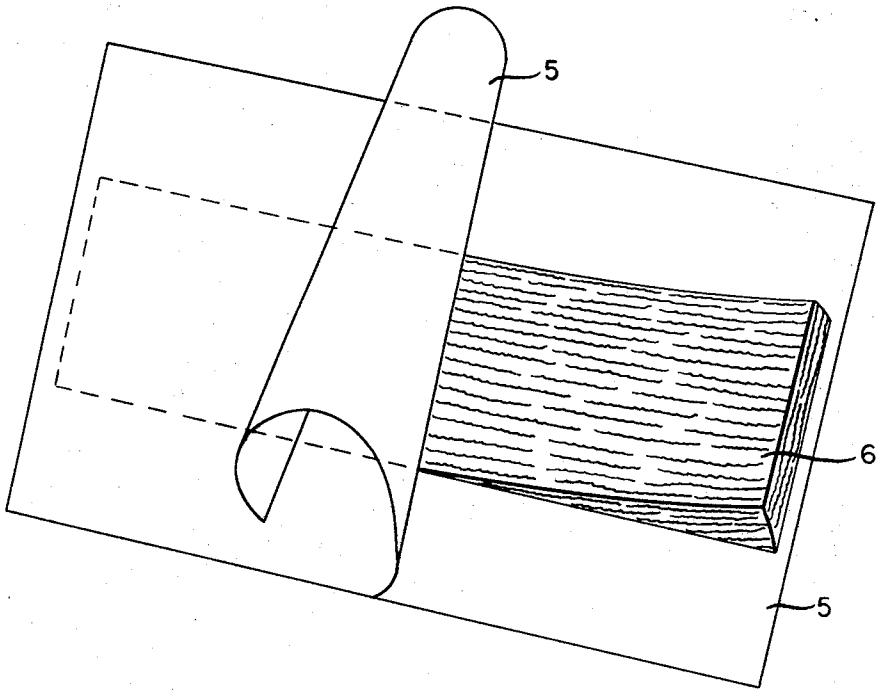
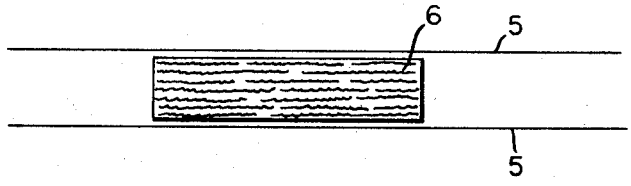


FIG. 7



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3,521,638

FABRICS HAVING WATER SOLUBLE DISCRETE AREAS AND METHODS OF MAKING

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Continuation-in-part of application Ser. No. 594,134, Nov. 14, 1966. This application Feb. 10, 1969, Ser. No. 801,922

Int. Cl. A61f *13/16;* D06c *1/04;* D04h *17/00*

U.S. Cl. 128—284 14 Claims

ABSTRACT OF THE DISCLOSURE

Cellulosic fabric is treated with a chemical modifying agent in a pattern to convert cellulose fibers to water-sensitive cellulose derivative fibers dividing the fabric into areas of water-resistant cellulosic fibers. Fabric is provided which has substantial strength when dry or wet with body fluids but which disintegrates into flushable pieces when wet with water in a home flush toilet. The fabric is useful in single-use products such as diapers, catemenical devices, bandages and undergarments.

REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of my copending application Ser. No. 594,134 filed Nov. 14, 1966 now abandoned.

This invention relates to textile fabrics for single use purposes.

Single use devices intended for the absorption of body fluids such as diapers, bandages, sanitary napkins, tampons and the like are generally constructed of an absorbing body and a cover. Such covers must have sufficient strength to maintain the integrity of the device in use. In general, conventional covers have a sufficient wet strength to maintain their integrity in turbulent water and hence make disposal in a home sewer line a hazardous experiment.

This invention provides fabrics and structures which have adequate strength and durability in use and are suitable for disposal in sewage systems after use. These flushable fabrics are characterized by a wet tensile strength of less than 0.1 lb./in. (18 g./cm.) and preferably less than 0.07 lb./in. (12.5 g./cm.).

One product of this invention is an integral fabric having a plurality of discrete areas of water resistant cellulosic fibers, said areas having a maximum dimension of less than 2 inches (5 cm.) each and being surrounded by areas containing at least 50% by weight of water-sensitive, cellulose derivative fibers having a degree of substitution of at least 0.2 and comprising up to 90% of the area of the fabric.

Another product of this invention is an integral nonwoven fabric consisting essentially of fibers aligned primarily in one direction, said fabric having a plurality of discrete bands transverse to the direction of fiber alignment, each having a width less than about 0.5 inch (1.26 cm.) and consisting essentially of water-resistant cellulosic fibers, said bands alternating with water-sensitive bands containing at least 50% by weight of cellulose derivative fibers with a D.S. of at least 0.2, the area of the water-sensitive portions comprising up to 90% of the total fabric area.

The fabrics are characterized by substantial strength when dry and upon exposure to body fluids, but disintegrate into flushable pieces upon being subjected to a water stream in a toilet. Preferably the water-sensitive cellulose derivative is the sodium salt of carboxymethyl

cellulose having a degree of substitution of between 0.2 and 0.8.

By the expression "water-sensitive, cellulose derivative fibers" is meant cellulose ethers and cellulose esters having a degree of substitution of at least 0.2 and having an absorbency of from 5 to 30 or more grams of water per gram of fiber. The fibers can be water-soluble, but this is not preferred. Hydroxyalkyl ethers of regenerated cellulose and monovalent metal salts of carboxyalkyl ethers (with alkyl containing from 1 to 4 carbon atoms) of regenerated or acid degraded native cellulose are illustrative of the cellulose ethers. Suitable cellulose esters include monovalent metal salts of partial esters of inorganic and organic polybasic acids such as: sodium cellulose phosphate, sodium cellulose sulfate, sodium cellulose hemisuccinate, sodium cellulose hemiphthalate, sodium cellulose hemiglutarate, and sodium cellulose hemimaleate as well as substitution products of the above dibasic acids. Cellulose ethers and esters containing a monovalent metal salt group are preferred.

By the expression "water-resistant cellulosic fibers" is means cellulosic fiber having an absorbency of less than about 4 grams of water per gram of fiber. Cotton and rayon (absorbency of about 3 grams/gram) are most conveniently used. However, cellulose that has been modified to a degree of substitution (D.S.) of less than 0.1 with any ether or ester groups or to a D.S. of less than about 0.4 with free acid groups (e.g., acid carboxymethyl-) can be used.

It is preferred that the water-sensitive areas do not exceed about sixty percent of the entire fabric (as calculated using an area containing at least 16 discrete areas or units), and more preferably, these areas will not exceed about 40% of the fabric area. The water-sensitive areas are kept to a minimum since when dry they are not as soft against the skin as the unmodified portions and, furthermore, exposure to body fluids creates a certain slimey effect at the water-sensitive areas. The areas will have a width from about 1 to about 5 mm. They can be wider but are preferably no wider than about 20% of the average staple length for nonwoven fabrics made of staple fibers.

The absorbency is determined by soaking a sample in an excess of distilled water at 25° C. (e.g. 1 gram in 3 liters of water). The sample is removed from the liquid and spread over a 5 x 5 cm. area on blotting paper and loaded with a 3 kilogram weight to give a pressure of 112 g./cm.^{2} for five minutes. The sample is removed, weighed ("wet") and dried to constant weight ("dry") using a Noble and Woods sheet dryer at 100° C. Absorbency equals the water absorbed (wet weight minus dry weight) divided by the dry weight.

The fabrics of the invention are characterized by a minimum dry tensile strength of at least about 0.2 pound/inch (36 gram/centimeter) in at least 1 direction. The fabrics will have a tensile strength in synthetic urine in both the machine and cross directions of at least 0.02 lb./in. (3.6 g./cm.), and a basis weight of from about 0.4 to 5.0 oz./square yard (13.5 to 170 grams/square meter) and preferably about 0.8 to 2.0 oz./yd.^{2} (27 to 68 g./m.^{2}). By "integral" is meant that the individual fibers are firmly held in the fabric so that gentle abrasion of the dry fabric, and even when wet with a body fluid, does not cause excessive loss of fibers.

FIG. 1 is a schematic sketch of the starting fabrics suitable for use in this invention made up of fibers **1**, restraining junctions **2**. The restraining junctions may be afforded by the crisscrossing of warp and fill yarns in a woven fabric, the loops in a knitted fabric, areas of entangled fibers or by water-resistant bonds such as resins.

FIG. 2 is a schematic sketch of a product of this in-

vention made by applying a modifying agent to a nonwoven directional cellulose fiber fabric in programmed areas 3 to produce fiber segments of water sensitive cellulose derivative. Water resistant resin bonds 2 in continuous or discontinuous lines across the fabric provide wet strength in the cross direction.

FIG. 3 is a schematic sketch of a product of this invention in which modified portions appear in both major directions of the fabric. Such a product is made by applying a modifying agent in a pattern to the product of FIG. 1 to produce water-sensitive cellulose derivative fibers.

FIGS. 4 and 5 illustrate a sanitary napkin comprising an absorbent core covered with the flushable fabric of the invention as the outer wrapper 5 which has end extensions forming attachment tabs in the usual manner. Within the cover, there is the absorbent core formed of a composite of absorbent creped tissue 7 known as a cellulose wadding and loosely felted fibrated wood pulp 6 commonly known as fluff. The thickness and composition of each of these absorbent layers may vary considerably and may be interchanged in position or have one or the other type omitted depending on how much total absorbent capacity and softness is desired in the core. All components of the core must be water dispersible. Between the core and the bottom and sides of the napkin wrapper is creped tissue 8 which has been treated with a hydrophobic material to act as a menstrual fluid barrier.

FIGS. 6 and 7 illustrate a diaper comprising an absorbent core covered with a wrapper 5 consisting of the flushable fabric of the invention. The core consists preferably of wood fluff 6 but can be any fiber blend or composite which is water dispersible.

SUITABLE STARTING FABRICS

Fabrics containing primary regenerated cellulose fibers as their fibrous constitutent, are suitable for making one embodiment of this invention. The fabrics may be woven, knitted or nonwoven. The latter are preferred.

Nonwoven fabrics are those products produced from staple fibers or continuous filaments without the use of conventional weaving or knitting operations. The usual starting material for nonwoven fabrics is a basic web of staple-length fibers. Such webs are made by carding, air deposition, or liquid deposition of the fibers and may vary from complete randomness to complete alignment. The fibers usually have an average length of from 0.5 to 2.5 inches (1.27 to 6.35 cm.) but some processes may use fibers as short as 0.25 inch (0.635 cm.) or as long as 6 inches (15 cm.) The single webs can be combined to form a layer of different fiber alignment, different composition or different type, such as the combination of a continuous filament web and a staple fiber web.

The basic web ordinarily has little strength and must be treated to provide restraining junctions or bonds for the individual fibers. One way of doing this is by the application of a binder or adhesive to the web. This application can vary from single parallel lines or a grid of lines as taught by Goldman, U.S. Pat. No. 2,039,312, to a more sophisticated pattern of binders applied to both sides as shown, for example, by Griswold U.S. Pat. No. 3,120,449. Generally, the distance between bonded areas must be slightly less than the average length of the fibers and may only be a small fraction of the fiber length. The preparation of such webs and bonding of them is well known in the art. The book "NonWoven Fabrics" by F. M. Buresh, published by Reinhold Publishing Corporation, New York, N.Y. in 1962, provides a basic teaching and a large bibliography.

Restraining junctions may also be provided by the entangling and interlocking of fibers at discrete areas or lines. The needle punching technique as used on felts may be used, but is generally not too efficient for the light weight webs of this invention. A recent development uses fine, essentially columnar, liquid streams at relatively high pressures to entangle the fibers. The method of Belgian Pat. No. 673,199 of June 2, 1966, can be used.

Bonding of a simple web of fibers provides nonwoven fabrics that are useful but lack the appearance and handle of conventional textile fabrics. To improve on these qualities, the structures may be patterned or textured. The bonding of the fibers and patterning of the fabric can be done simultaneously by supporting the initial web on an apertured patterning member while traversing the web with fine, essentially columnar, liquid streams until the fibers are entangled in ordered groups. The patterning member may have a planar or nonplanar surface.

Patterning or texturing alone without any substantial amount of bonding may be done by subjecting the fibers in the basic web to a stream of fluid particles in a rearranging zone as taught by (Kalwaites) U.S. Pat. No. 2,862,251 by the method of (Gelpke) U.S. Pat. No. 3,137,893, or by the method of (Kalwaites) U.S. Pat. No. 3,081,501, for example. The patterned web can then be bonded with adhesives as discussed above.

The regenerated cellulose employed for the fabrics may be of the viscose rayon, cuprammonium rayon type, or any other regenerated cellulose and may consist of continuous filaments, spun staple yarns or preferably staple length fibers of from about 0.25 to 6 inches (0.63 to 15 cm.) in length coupled together by entanglement, autogenous bonds or a resin binder. The fibers will generally be of from 0.75 to 5 denier per filament. Minor amounts, up to 50% or other fibers such as cotton, nylon, acrylics, wood pulp and the like can be used in combination with the regenerated cellulose provided that such inert fibers are less than 0.5 inch long (1.26 cm.), preferably 0.25 inch (6.3 mm.) or less. It will be understood, of course, that the type, quantity and degree of entanglement of such additional fibers must not interfere with flushability; as more particularly described below. Such fabrics may be treated directly for modification without preliminary preparation as is required for cotton fabrics.

Where the starting fabric is cotton (native cellulose), certain pretreatments are required prior to modification as described below. Thus, it must first be dewaxed, then degraded with acid and then treated with alkali. After water washing it is now ready for modification.

MODIFICATION PROCESS

The water sensitive cellulose derivatives that may be formed in the process of this invention include monovalent metal salts of carboxyalkyl ethers, monovalent metal salts of partial esters of polybasic acids and hydroxyalkyl ethers (e.g., hydroxyethyl cellulose). Such derivatives and general means of preparing them are discussed in "Cellulose" Part II by Ott and Spurlin published in 1954 by Interscience Publishers, Inc., of New York, N.Y.

Both the regenerated cellulose fabrics and the cotton fabric treated as described above must be treated with a swelling agent and a solvating agent to make them reactive enough to react with etherifying agents. Sodium hydroxide is the usual swelling agent and water is the usual solvating agent for etherification of cellulose. The fabrics can be treated with the swelling agent in the desired areas and the etherifying agent in the form of a liquid or a gas then applied to the entire fabric or to discrete areas. The treated fabric is neutralized and dried.

Preferred forms of cellulose ethers are the alkali metal salts of carboxyalkyl ethers of regenerated cellulose with sodium carboxymethyl cellulose being more preferred. Fibers of cellulose ethers containing ionizable substituent groups are preferred since such fibers swell more in water than in body fluids such as blood or urine. In certain D.S. ranges (0.2 to 0.6 for NaCMC), these fibers yield fabrics which have adequate in-use strength in body fluids but essentially dissolved in the water of a toilet.

Alkali and chloroacetic acid or sodium chloroacetate are used for carboxymethylation. The reactants can be placed on the cellulose in any sequence. However, it has

been found that a single aqueous solution of sodium chloroacetate and NaOH is preferred for this invention.

The concentration of the sodium chloroacetate (which should be freshly prepared) can range from about 5 to 30%. The concentration of NaOH can vary from about 2% to about 10%. The portion of the fibers to be etherified should be well wet with the single solution. The entire fabric can be pressed so that the treated portions have a press ratio (i.e., weight of fabric wet pressed/weight of original dry fabric) of from about 2 to 6 and preferably 2.0 to 4.0. The pressing is usually not needed when the reagents are applied as thin lines. The fiber containing the etherifying agent is then heated to dryness at a convenient temperature and time to produce the desired modifications. At temperatures of 110 to about 150° C. the time for carboxymethylation may vary from a few seconds to 10 minutes or longer.

For some applications it may be useful to add viscosity builders such as gums or water soluble polymers to the solutions. In these cases it is desirable to press the fabric to insure penetration before heating.

The modified fabric must be treated to remove unreacted caustic and leave the etherified portions of the fibers in the NaCMC form. This can be accomplished in one step by using a buffered solution of the proper pH or by neutralizing with an acid weaker than monochloroacetic acid such as acetic acid itself. Alternatively the fabric can be treated with a strong acid such as H_2SO_4 and the thus obtained acid form of CMC converted to the salt form with a mild alkali—preferably a buffered solution.

The water sensitivity of the product must be considered when selecting the exact process following etherification. The acid form of CMC—as obtained by H_2SO_4 treatment of the carboxymethylation product—is relatively insensitive to water and can be washed with water. The salt form of CMC will vary from being very high swelling in water to water-soluble. Any treatments of the salt form must be done with a fairly concentrated salt solution or with a non-aqueous solution. Also the salt form of CMC must be dried in the presence of a fairly concentrated salt solution or in the presence of a water miscible organic compound such as acetone or alcohol to prevent hornification of the product and fusing of filaments.

Sodium sulfate is an efficient and economical source of the above mentioned salt solution. Other alkali metals or ammonium may serve as the cation of the salt in combination with sulfate, citrate, borate, phosphate and less preferably acetate as the anion. The salt solution should preferably be at least 0.7 molar.

It is preferred that the fabric be treated with a large excess of an aqueous agent at some time following etherification in order to remove by-products of the reaction which cause the fabric to be stiff, harsh and somewhat brittle.

The following are some specific ways of treating the fabric from etherification up to the point where it is ready for drying and use:

(I)

(A) etherification in desired areas
(B) bulk acidification of entire fabric or only the etherified areas with a strong acid such as sulfuric acid
(C) washing of entire fabric with water
(D) conversion to NaCMC form of etherified areas. This can be accomplished by treating the entire fabric with a fairly concentrated salt solution containing a mild alkali or preferably a buffered solution, or by application of the solution, as by printing, to the discrete etherified segments only.

(II)

(A) etherification in desired areas
(B) neutralization of unreacted alkali with a fairly concentrated salt solution containing a buffered solution to leave the CMC in a salt form by application of the solution to the entire fabric or only to the discrete etherified segments as by printing.

A buffered solution can be used to neutralize unreacted alkali and leave the CMC fiber in the salt form or it can be used to convert the acidic form to the salt form.

The buffering action is afforded by a mixture of a weak acid or a weak base and its salt. Suitable systems will be obvious to those skilled in the art and include the following to mention a few: potassium acid phthalate-dipotassium phthalate (pH 5.0 to 6.2), sodium dihydrogenphosphate-disodium hydrogen phosphate (pH 5.9 to 8.0), Boric acid-Borax (pH 6.8 to 9.0), disodium hydrogen phosphate-citric acid (pH 5–8), citric acid-sodium citrate, and sodium bicarbonate Na_2CO_3. Such systems are normally made by titrating one of the components with a strong base or acid to the desired pH level.

The final product wet with salt solution is pressed and dried and may be softened by mechanical working which also serves to remove excess salt.

For cellulose ethers in general the D.S. for the etherified portions should be at least 0.2 and preferably at least 0.4. The etherified portions when constituted by the sodium salt of carboxymethyl cellulose in the products of this invention should have a degree of substitution (D.S.) of between 0.2 and 0.8 and preferably between about 0.3 and 0.6. These values of degree of substitution delineate materials that withstand the effects of body fluids while swelling in water with marked loss of strength. It will be understood that due to the diffusion of the etherifying reactants along the fibers there will be a gradient of decreasing D.S. as one moves from the center of application of the reactants towards the unreacted cellulose.

Cellulose phosphate may be prepared by treating the cellulose fibers with phosphoric acid and urea applied as an aqueous solution containing from about 15 to 90% water, the weight ratio of acid, calculated as H_3PO_4, to urea being within the range 1:6 to 1:2. The impregnated fabric is then heated from about 125° C. to about 210° C. until the cellulosic fibers have a D.S. of at least 0.2. The modified areas can be washed with water and then converted to a water-sensitive form by at least partially neutralizing.

Cellulose sulfate can be prepared by the reaction of sulfuric acid (or sulfamic acid) and urea on the cellulose fibers.

Hemi-esters of dibasic organic acids such as succinic, phthalic, glutaric and maleic may be made by applying an amic acid (carbamyl acid) of the above acids such as succinamic acid to the cellulose and then heating from about 120° C. to about 210° C. A catalyst such as sulfamic acid, p-toluene sulfonic acid, zinc chloride, magnesium chloride and the like may be used.

Hemi-esters of dibasic organic acids can also be made by impregnating the cellulose with a concentrated solution of a partial ammonium salt of the acid and heating above 160° C. The solutions are conveniently made by dissolving the acid anhydride (e.g., succinic anhydride, O-phthalic anhydride, or maleic anhydride) in a mixture of water and ammonium hydroxide (1–1.5 moles NH_3 per mole of anhydride).

The products of this invention are useful as diapers, covers for catamenial devices such as sanitary napkins and tampons, as single use undergarments, bandages and the like. They may be used alone or in combination with absorbing elements such as wood fluff, batts or nonwoven structures of highly hydrophilic fibers.

TESTING PROCEDURES

Samples used for dry tensile tests, and basis weight are conditioned at 70° F. (21° C.) and 65% relative humidity for at least 24 hours before testing under these conditions.

Tensile strengths and elongations are measured on 1.0 x 2-inch samples (having a water-sensitive band across

their width) at an elongation of 50% per minute on an Instron testing machine. The results are in pounds/inch, hereafter designated as lbs./in.

Samples are soaked for 5 minutes in distilled water or other liquid at 21° C. and then clamped in the tester and broken in air to determine wet strip-tensile strength in water. In determining wet tensile strength in synthetic urine, the soaking is done in synthetic urine.

Basis weights are expressed in ounces/square yard, hereafter designated as oz./yd.^{2}, and are based on the weight of the dry fabric as measured.

For the purposes of this invention and to evaluate the effects of body fluids on the fabrics, a salt solution termed "synthetic urine" with a composition similar to human urine [10 g. NaCl, 24 g. urea, 0.6 $MgSO_4$, and 0.7 g. calcium acetate monohydrate per 964.7 g. distilled water] was employed.

A solution termed "synthetic hard water" containing 0.4 g. of calcium acetate monohydrate and 0.175 g. of $MgSO_4$ in 999.4 g. of distilled water is used in some tests.

The dispersibility is determined in a 250 ml. filter flask having an additional side arm at the bottom of the conical wall and containing a magnetically rotated bar. The bar is 3.8 cm. long by 8 mm. in diameter, weighs 11.73 grams and is rotated at 500 revolutions per minute. A sample is inserted under the surface of the water (at the top side arm). Water at about 25° C. is added through the bottom tube at a rate of 0.70 liter/minute for a period of 2 minutes unless otherwise indicated.

Samples are tested for disposability in a home sanitary system by the following procedure: A portion of a fabric of the size used as a diaper or a sanitary napkin cover is dropped into the bowl of a household toilet (model F 2122 made by American Radiator and Standard Sanitary Corporation of New York, N.Y.) and flushed. The discharge from the toilet is passed through a 2.33 ft. length of glass pipe (10.8 cm. I.D.) containing a 1-foot long hollow cylinder (about 10.8 cm. O.D.) with 0.5 in. (1.27 cm.) wide diamond perforations and provided with 41 inside projections randomly distributed and made by making parallel pairs of cuts about 0.25 to 0.75" (0.63 to 1.9 cm.) long and about 0.3" (0.76 cm.) apart, and bending the cut sections to stand perpendicular to the walls of the cylinder. One flushing gives a flow rate of 18–20 liters of water in 20 seconds. The toilet is flushed 3 times for each sample. A sample is termed "flushable" if at least 80% passes by the hooks after two passes.

For nonwoven fabrics the ratio of the force to break a long length (F_1) to the force to break a "zero" length (i.e., when the jaws of the tester are touching) (F_0) is termed completeness or *c* and is a measure of the integrity of the fabric. For the test all samples are cut 1.8 inches (4.1 cm.) wide and samples are broken in an Instron testing machine at jaw separations of 1.5" (3.8 cm.) and 0" using an elongation rate of 0.5" (1.27 cm.) per minute. The breaking force of 5 samples cut from 1 direction in the fabric and of 5 samples cut in a direction 90° to the first are averaged. A *c* value of 1.0 means that all fibers are being utilized for strength. A *c* value below 0.05 indicates that no fibers are breaking and the failure occurs by slipping of the fibers.

Example I

Rayon fibers of 1.56" (3.94 cm.) length and 1.5 d.p.f. are made into a batt of randomly oriented fibers by an air deposition process using a Rando-Webber machine (made by Curlator Corp. of East Rochester, N.Y.). The batt has a basis weight of 1.0 oz./yd.^{2} (33.9 g./m.^{2}). The batt is given integrity by supporting it on a fine screen (80 x 80 mesh per inch having 16% open area) and passing it twice at 3 feet (92 cm.) per minute under a row of columnar water streams. The streams are formed by water at 400 pounds per square inch (28 kg./cm.^{2}) passing through a row of orifices spaced 20/inch (20/2.54 cm.) and located about 2.5 cm. above the fabric. The orifices are etched and have a diameter of 7 mils (0.18 mm.). The thus hydraulically entangled fabric is squeezed of excess water and tumble dried at 60° C. The dry structure resembles a thin felt but has the strength and integrity of a woven fabric.

An aqueous solution (freshly prepared) containing 20% sodium chloroacetate and 3% NaOH is applied from a No. 22 hypodermic needle along lines defining a 1 inch (2.54 cm.) square grid pattern on a portion of the fabric. Sufficient solution is applied to saturate the fabric at the lines. The fabric is placed on a Noble and Woods textile sheet dryer at 120° C. for 4 minutes. It is then washed for 2 minutes in an aqueous bath containing 5% H_2SO_4 and 15% Na_2SO_4. It is then neutralized in an aqueous solution of 3% Na_2HPO_4 and 17% Na_2SO_4 that has been adjusted to a pH of about 8.4 with 20% NaOH. Excess liquid is rolled from the fabric under compression and it is dried at about 22° C. The product contains a grid of intersecting lines (4 mm. wide) on 2.54 cm. centers of sodium carboxy methyl cellulose (NaCMC) fibers separated by unmodified rayon fiber squares (71% of the total fabric area). The NaCMC segments are estimated to have a D.S. of about 0.3 based on results with similar rayon fibers. The etherified segments are transparent when the fabric is wet.

The product has appearance, softness, and drape of the unmodified product. The dry strength of the unmodified fabric is 1.3 lb./in. (0.23 kg./cm.) as compared to 1.44 lbs./in. (0.256 kg./cm.) for the modified product. The modified product has a wet strength in hard water and urine of 0.08 and 0.15 lb./in. (14 and 25 g./cm.) respectively. The strength in distilled water is too low to measure [less than about 0.005 lb./in. (0.18 g./cm.)].

The fabric breaks up into 1 inch (2.5 cm.) squares of unmodified fabric in the turbulent water, of the dispersibility test within 30 seconds. A 6 x 16 inch (15 x 40 cm.) sample is 100% flushable in the test toilet.

The product having discrete areas of the acid form of carboxyalkyl ethers surrounded by discrete areas of the water-sensitive salt form may be made by saturating the entire non-woven rayon fabric of Example I with the solution containing sodium chloroacetate and NaOH, removing excess liquid and heating to dryness at 120° C. The resulting uniformly etherified fabric is washed with a strong acid (e.g. H_2SO_4), rinsed with water and dried. Discrete areas of the fabric are converted (e.g. by printing or applying solution from a hypodermic needle) to NaCMC form by treatment with a mild alkali or a buffered solution to yield discrete areas of CMC (acid form) surrounded by discrete areas of NaCMC (salt form).

Example II

Hand sheets (A) with a basis weight of about 1 oz./yd.^{2} (33.9 g./m.^{2}) are made from rayon staple of 0.25 inch (0.64 cm.) length from a slurry of 1.5 grams of the fibers in 7 liters of water.

Hand sheets (B) are made from 3 d.p.f. nylon fibers of 0.25 inch (0.64 cm.) length in a similar manner.

Hand sheets (C) are made from cotton fibers of 0.25 inch (0.64 cm.) length from a slurry containing 1.5 grams of fibers, 30 g. Na_2CO_3, 0.04 g. cyanoethyl cellulose fibers (as a binder) in 7 liters of water.

A double-layered structure (A–B) is made by placing a layer of paper A on a 30 x 30 mesh screen (53% open area) covering with sheet of paper B and hydraulically entangling the structure with the apparatus of Example I at 200 p.s.i. (14 kg./cm.^{2}) pressure. The procedure is repeated to make a structure A–C at 250 and 400 p.s.i. (17.5 and 28 kg./cm.^{2}) and A–A (i.e. 100% rayon) at 250 and 450 p.s.i. (17.5 and 31.5 kg./cm.^{2}). The entangled non-woven fabrics have basis weights of about 1.9 oz./yd.^{2} (65 g./m.^{2}).

An aqueous solution containing 30% sodium chloro-

acetate and 3% NaOH is applied from a No. 22 hypodermic needle along lines defining a 1 inch (2.54 cm.) square grid pattern on a portion of the fabric. The weight of the fabric thus marked is about 2.1 times its original, dry weight. The fabrics are heated to dryness, washed in acid-salt solution, and neutralized as in Example I. The fabric is tumble dried at 60° C.

The discretely-etherified fabrics A–A, A–B and A–C break up into the 1 inch squares in 15 seconds, 15 seconds and 2 minutes respectively. Samples of the unetherified, original entangled fabrics show no change after 2 minutes in the turbulent water of the dispersibility test.

Example III

Carded batts, 1 oz./yd.^{2}, comprised of 1 9/16" rayon staple are hydraulically entangled with water.

The fabric is post-modified along interesting lines defining ½" squares by applying a solution of freshly prepared 20% sodium chloroacetate and 3% sodium hydroxide with a No. 22 hypodermic needle along these lines. The treated fabric is baked on a Noble and Wood sheet dryer at 120° C. for 5 minutes. The fabric is washed in an aqueous solution of 5% H_2SO_4 and 15% Na_2SO_4. The acidified fabric is subsequently washed in water and neutralized to faint pink phenolphthalein in an aqueous solution of 3% Na_2HPO_4 and 17% Na_2SO_4 prior to a final wash in 15% Na_2SO_4. After couch rolling the fabric is tumble dried for 30 minutes at 60° C.

The post-modified grid lines are readily discernible in water from the untreated portion of the fabric by the transparency of the high swelling post-modified fibers. Based on the width of the grid lines when the sheet was wet the post-modified area is 55.0%. In the dispersibility apparatus, the fabric breaks up into unmodified squares in less than 30 seconds. A measurement of pH shows that this fabric is neutral—7.0.

A diaper based on this fabric was fabricated by sandwiching 15.0 g. of wood fluff between two 9½ x 14" pieces of fabric. The integrity of the wet diaper was subjectively rated as good in synthetic urine and was fully flushable in a toilet.

Example IV

Conventional shaped sanitary napkins were constructed by wrapping a 7 x 19" piece of the ½" grid modified fabric described in Example III entirely around 12 g. of wood fluff. Crepe wadding (1.35 oz./yd.^{2}) coated with approximately 0.2 of poly-fluoro-alkyl methacrylate was wrapped around the sides and bottom of the wood fluff insert prior to encapsulation by the napkin cover. All the components of the napkin were completely dispersible and the napkin itself is fully flushable in a toilet.

Example V

A rayon cloth 16 inches x 16 inches containing 110 warp ends and 72 filling ends per inch of 75/30/3 Z dull rayon in a plain taffeta weave, with a basis weight of 1.7 oz./yd.^{2} was given a preliminary boil-off in 0.1% "Tide" solution to remove any finishing material still on the cloth. The modifying solution applied contained 20% sodium chloroacetate, 5% sodium hydroxide and 0.75% high-viscosity sodium CMC as a thickener to retard wicking. The solution was applied in thin lines ½" apart in a grid pattern, using a hypodermic syringe and a template. The solution was allowed to soak in for 1 to 1½ minutes, and the cloth was baked 5 min. at 125° C. The dried grid-modified fabric was dipped directly into a neutralizing bath containing 17% sodium sulfate and 3% disodium phosphate adjusted to a pH of 8 to 8.5. The cloth was then squeezed dry as possible and dried at about 80° C.

In the standard dispersibility test, the cloth broke up into ½" tabs which would be easily flushable in a standard toilet. A 1" strip of the dry fabric easily supported a 3-lb. load, and when soaked in synthetic urine it supported 0.09 lb. in both warp and weft directions. This indicates adequate strength-in-use for disposable diapers.

The unmodified areas were measured to be about 18 mm. square, separated by grid lines about 3 mm. wide. This calculates to be 46% modified area.

Example VI

A portion of the batt of Example I (unentangled) is given integrity by supporting it on a fine screen (30 x 30 mesh per inch having 48% open area) and passing it twice at 3 feet (92 cm.) per minute under a row of columnar water streams. The streams are formed by water at 200 pounds per square inch passing through a row of orifices spaced 40/inch (40/2.54 cm.) and located about 2.5 cm. above the fabric. The orifices are conical and have a diameter of 5 mils. The thus hydraulically entangled fabric is squeezed of excess water and tumble dried at 60° C. The dry structure has the strength and integrity of a woven fabric with a c value of 0.3.

A thickened aqueous solution (freshly prepared) containing 20% sodium chloroacetate, 4% NaOH and 0.5% high-viscosity sodium CMC as thickener is poured into a mold supporting a silk screen. The silk screen is constructed in such a manner to allow the steeping solution to pass through perpendicularly intersecting lines 0.125" (3.2 mm.) wide separated by 0.5" (12.7 mm.) squares of impermeable material. The rayon fabric, placed under the screen, is saturated with the solution along these lines by drawing the solution across the screen with a rubber squeegee. The fabric is pressed to remove excess solution and heated as in Example I. It is then washed, neutralized, and dried as in Example III.

The product contains a grid network of 0.125" (0.32 cm.) intersecting lines comprised of NaCMC fibers separated by 0.5" (1.2 cm.) squares of unmodified rayon. The modified area is 36% of the total area and the NaCMC segments are estimated to have a D.S. of 0.43 based on results with similar rayon fibers. The carboxymethylated segments are transparent in water. The sharpness of the lines confirm that the thickener has prevented the steeping solution from lateral wicking after application.

The product has appearance, softness, and drape of the unmodified product. The dry strength of the modified product is 2.7 lbs./in. compared to 1.4 lbs./in. (0.48 vs. 0.25 kg./cm.) for the original fabric. The wet strength of the modified fabric depends on the swelling medium: 0.025, 0.055 and 0.075 lb./in. (4.5, 9.8, and 13.3 g./cm.) in synthetic hard water, cow's blood, and synthetic urine, respectively. The fabric disseminates into ½" rayon squares within 10 seconds in the turbulent water of the dispersibility apparatus.

When the above unmodified, entangled nonwoven is replaced with one entangled under more severe conditions to a c value of 0.6, and similarly etherified, the final product has a dry tensile of 2.64 lbs./in. (0.47 kg./cm.) and a wet tensile of 0.024 lb./in. (4.3 g./cm.) in hard water. The modified fabric disseminates into the rayon squares within 30 seconds in the turbulent synthetic hard water of the dispersibility apparatus.

Example VII

Sodium chloroacetate-NaOH solution is applied using the technique of Example VI to the rayon nonwoven fabric described in that example. The fabric is pressed to remove excess solution and heated on a Noble and Wood Textile Sheet Drier at 120° C. for 4 minutes. An aqueous 2% H_2SO_4 solution is applied to the carboxymethylated intersecting lines with a No. 22 hypodermic needle. In a similar manner the fabric is neutralized on the post-modified lines with an aqueous solution of 3% Na_2HPO_4 and 17% Na_2SO_4 that had been adjusted to a pH of 8.4 with 20% NaOH. Excess buffer is rolled from the fabric under compression and the fabric is tumbled dried at 60° C.

The product exhibits hydrophilic and physical proper-

ties similar to those described in Example VI. The only exception is that the unmodified rayon has never been exposed to the saline solutions and aesthetics are improved over the bulk neutralized product. Omission of the intermediate acidification step results in fabrics which are brittle at the carboxymethylated grids.

Example VIII

Rayon fibers of 1.56 in length and 1.5 d.p.f. are made into a batt of randomly oriented fibers by an air dispersion process similar to that described in Example I. The batt has a basis weight of 1.0 oz./yd.^{2}. An aqueous solution of 8% sodium hydroxide is applied from a No. 26 hypodermic needle along intersecting lines defining a 0.25" (6.4 mm.) square grid pattern on a portion of the fabric. The batt is next grid modified according to the procedure outlined in Example VI. The product resembles a thin felt but has the strength and appearance of a fabric.

Examination under a microscope shows that in contrast to the fibers in the carboxymethylated grid, the fibers dried down from the 8% sodium hydroxide solution during the baking process have densified to give the batt its integrity. In water both bonded and carboxymethylated regions are transparent but only the etherified grids have low strength.

The dry strength of the bonded grid-modified batt is 1.7 lbs./in. (0.3 kg./cm.). The wet strength of the structure is 0.014 and 0.04 lb./in. (2.5 and 7.2 g./cm.) in synthetic hard water and synthetic urine, respectively. The fabric breaks up into 0.5" (1.26 cm.) rayon squares within 30 sec. in the turbulent water of the dispersibility apparatus.

Example IX

A rayon nonwoven fabric (entangled at 300 p.s.i., 5 ft./min.) is printed with a solution of 20% sodium monochloroacetate/6% sodium hydroxide/0.25% of a polysaccharide gum used as a thickening agent ("Kelzan" made by the Kelco Co. of Chicago, Ill.) at a speed of 13 ft. (4 meters) per minute. The print roll is engraved to a depth of 0.010" (0.25 mm.) with a grid pattern consisting of 0.0625" (ca. 1.6 mm.) wide lines on 0.5" (1.25 cm.) centers. After printing, this sample has a reactant solution pick-up (weight of solution per weight of fiber printed) of 6.1 to 1. The printed fabric is "crushed" between two sheets of polyethylene to insure both penetration of the reactants and merging of the lines due to the engraving within the desired line width. The "crushed" fabric is then baked in a forced air oven at 125° C. at a speed of 3 ft. (0.9 m.) per minute giving a baking time of 0.5 minute. After baking, a ten-gram portion of this sample is neutralized using 1 liter of 15% sodium sulfate/5% sulfuric acid and then 1 liter of 17% sodium sulfate/3% disodium hydrogen phosphate. The 17/3 bath is titrated to a phenolphthalein end point (pH 8.2–9.0) with sodium hydroxide with the sample in the bath.

The dry tensile strength of this sample is 1.7 lb./in. (0.3 kg./cm.). The wet tensile strength is 0.028 lb./in. in synthetic urine and 0.014 lb./in. in "hard" water (5 and 2.5 g./cm.).

Example X

An entangled, rayon, nonwoven fabric of the type made in Example I is marked off in 0.5" (1.26 cm.) squares (center to center) using 30% NaOH in a hypodermic syringe guided by a template. Excess caustic is removed by repeated couching between blotters. The fabric originally 1.03 g. dry, now weighs 1.77. It is suspended in a plastic bag containing essentially pure ethylene oxide vapor and allowed to react at room temperature for 1.75 hours. The fabric is acidified in 5% H_2SO_4/15% Na_2SO_4 solution and neutralized in 3% Na_2HPO_4/17% Na_2SO_4. It is couched between blotters and dried at about 40° C. The etherified lines (hydroxyethyl cellulose) have an area of about 29% of the total.

Strips of fabric cut 1 inch (2.54 cm.) wide parallel to the grid lines have a dry tensile strength of 651 g. (1.44 lb.) per inch width. After soaking 5 min. in synthetic urine, the wet strength is 11 g. (0.024 lb.) per inch.

A second similar sample weighing 0.80 g. dry and 1.48 g. after couching is reacted with ethylene oxide for 1½ hours. The final product has a tenacity in synthetic urine of 41 g. (0.09 lb.) per inch. The dry tensile strength was 742 g. (1.63 lb.) per inch.

Example XI

A comercial nonwoven fabric of 0.5 oz./yd.^{2} (16.9 g./m.^{2}) basis weight made by bonding a substantially random web of 0.375 inch (9.6 mm.) long rayon staple of about 1.5 d.p.f. ("Dexstar" No. 210) is used as the starting fabric.

The fabric is soaked in a solution containing 20% sodium monochloroacetate and 3% NaOH for 1 minute, drained and pressed between blotting papers. The damp sheet is placed on a wire grid at 150° C. for 10–15 seconds with etherification occurring where the sheet contacts the hot grid and dries. The sheet is then neutralized by placing in a 20% Na_2SO_4 solution and titrating to pH 8.5 with acetic acid.

The metal grid is from an expanded metal sheet that has been flattened to give a series of contiguous hexagonal shapes of metal strips equivalent to about 18–20 gauge wire. The shapes (between metal) have a length of about 2 cm. and a width of about 1 cm.

The product has the following properties:

	Tensile
Dry	6.5 lbs./in. (1.2 kg./cm.).
Wet in urine	0.12 lbs./in. (21 g./cm.).
Wet in hard water	0.039 lbs./in. (7 g./cm.).

Three 1" x 3" (2.5 x 7.5 cm.) strips placed in the dispersibility tester start to break up into hexagonal pieces after about 10 seconds. After 81 seconds there are only a few pieces containing more than 1 hexagonal shape.

The area of the etherified part of the sheet is about 23% of the total.

Example XII

This example demonstrates the removal of embrittling contaminants from etherified products.

A piece of nonwoven viscose rayon fabric weighing 2.27 g. is soaked 1 min. in 50 g. of a solution containing 20% sodium chloroacetate and 3% sodium hydroxide. It is squeezed out and pressed between blotters to a wet weight of 6.82 g. It is baked on a hot plate at 125° C. for 5 min. The bone-dry brittle sheet is soaked in 50 ml. of a solution containing 3% Na_2HPO_4 and 17% Na_2SO_4, adjusted to a pH of about 6.5 (low pH contributes to softness). The cloth is squeezed out thoroughly and dried flat. It is stiff, harsh and somewhat brittle. A portion of this cloth is washed in two liters of the same buffered salt solution with pH adjusted to 8.7, squeezed out and dried flat. The fabric is now relatively soft and no longer brittle.

To confirm the fact that the buffered salt solutions actually extract an embrittling contaminant, a piece of plain nonwoven rayon fabric is soaked in the 50 ml. extracting liquid, used above to soak the modified sheet, squeezed out, and dried flat. The fabric is markedly stiffened and harshened, and is brittle enough to crack slightly when first dried.

Example XIII

The fabric used was the outer cover scrim removed from a commercial sanitary napkin (Teenage "Modess"). The fabric was mildly patterned and consisted of rayon fibers all aligned in esentially one direction, held together by wavy lines of adhesive in the cross direction about 2 mm. wide and at a repeat distance averaging 6.5 mm. The fabric was treated between the adhesive lines, with narrow lines of a reagent solution applied with a hpyodermic needle guided by a straight edge. The reagent solution contained 15% sodium chloroacetate, 4% sodium hydrox-

ide and 0.425% high viscosity sodium CMC as a thickener to prevent spreading. A piece of the fabric weighing 0.84 g. (basis weight 0.53 oz./yd.^{2}) was treated with reagent and couched between blotters, after which it weighed 1.20 g. It was baked on a hot plate at 125° C. for 5 mins., acidified in 5% H_2SO_4/15% Na_2SO_4 solution and neutralized in 3% Na_2HPO_4/17% Na_2SO_4 solution. It was couched between blotters and dried flat at room temperature. The etherified lines were estimated to be 0.7 mm. in width at an average repeat distance of 6.5 mm., corresponding to 11% modified area. The tensile strengths of the modified fabric were as follows (in lbs./in.):

	Dry	Synthetic urine wet	Soft water wet
M.D	5.6	0.055	(1)
X.D	0.39	0.095	.066

[1] Too weak to test.

A sanitary napkin was made by folding a 5½ x 19" piece of the modified fabric around a wood fluff absorbent pad in the usual way. It passed the flushability test (soft water) without difficulty.

Example XIV

This example illustrates the process for making flushable fabrics from cotton fabrics.

El Paso combed cotton fibers are made into a batt of randomly oriented fibers by an air deposition process. The batt with a weight of 1.0 oz./yd.^{2} (33.9 g./m.^{2}) is given integrity by supporting it on a screen (24 x 24 mesh per inch) and passing it at 20 feet (6.1 meters) per minute under a row of columnar water streams. The streams are formed by water passing through a row of funnel-shaped orifices spaced 40 per inch (per 2.54 cm.) and located about 2.5 cm. above the batt. Each orifice comprises a cylindrical entrance of 5 mils (0.127 mm.) diameter about 1 mil (0.025 mm.) long with a frusto conical section 11 mils (0.28 mm.) long with an exit diameter of 15 mils (0.38 mm.). The batt is treated once at 50 p.s.i. (3.5 kg./cm.^{2}) and four times at 400 p.s.i. (28 kg./cm.^{2}).

The patterned and entangled nonwoven cotton fabric is dewaxed by boiling it for 30 minutes in a solution containing 3 grams home wash detergent ("Tide") and 6 grams of tri-sodium phosphate dodecahydrate in 3 liters of water, water washed and dried.

The dewaved nonwoven fabric is then degraded by soaking in 18.5% HCl at 70° C., water washed, acetone rinsed and dried.

The degraded fabric is then clipped to a stainless steel screen (to prevent shrinkage) and treated in 25% aqueous NaOH at 18° C. for 3 minutes, water washed, acetone rinsed and dried.

An aqueous solution containing 25% sodium chloroacetate, 10% NaOH, and 0.2% carboxymethyl cellulose as a thickener is applied to the fabric through a silk screen to give 3/32" (2.5 mm.) lines in a square grid surrounding fabric 0.5 inch (1.27 cm.) on the side. The lines constitute 29.1% of the fabric area. The fabric is then heated at 125° C. for 5 minutes, rinsed in an aqueous solution containing 5% H_2SO_4 and 15% Na_2SO_4 followed by an aqueous solution containing 3% Na_2HPO_4 with 17% Na_2SO_4 and then a solution containing 3% Na_2HPO_4 and 17% Na_2SO_4 adjusted to a pH of 8.5. The fabric is tumble dried in a home laundry dryer. The product, items *a* and *b*, have a grid of sodium carboxymethyl cellulose of D.S. of 0.58 and 0.54, respectively, surrounding squares of unetherified, acid-degraded cotton.

Details of the process and properties of the final product are given in Table I.

The above procedure is repeated starting with a woven cotton cheesecloth having a fabric weight of 1.2 oz./yd.^{2} (41 g./m.^{2}) to give items *c–g* in Table I.

The wet pickup ratio for the grid carboxymethylation (W.P.U.R.) is calculated as

$$\text{W.P.U.R.} = \frac{\text{weight of fabric wet with reagent} - \text{original dry weight}}{\text{original dry weight (fraction of fabric area containing reagent)}}$$

Tensile properties are measured on samples cut at 45° to the grid lines in the dry state, in synthetic urine and in tap water.

Items *e*, *f*, and *g* are included to show the criticality of the process steps. Items *e* and *f* use only one of the pretreatment steps and do not give a flushable product as indicated by no breakup in the turbulent water of the dispersibility apparatus in 5 minutes. Item *g* is a borderline product.

TABLE I

	Pre-etherification treatment			Properties of final product			
				Tensile lbs./in. (g./cm.)			
	Acid time, sec.	NaOH	Etherification, W.P.U.R.	Dry	Synthetic urine	Tap water [1]	Dispersibility,[2] percent/seconds
Item:							
a	60	Yes	4.7	1.6(286)	0.03(5.3)		100/10
b	30	Yes	4.1	2.5(445)	0.04(7.1)	0.007(1.25)	100/20
c	90	Yes	4.1	4.3(765)	0.08(14.2)	0.004(0.71)	100/120
d	90	Yes	5.5	4.8(856)	0.06(10.6)		100/90
e	60	No	5.0				0/300
f	0	Yes	3.7				0/300
g	60	Yes	3.2				80–90/300

[1] Items *a* and *d* were too weak to test.
[2] Breaks up into pieces of unetherified, acid-degraded cotton under conditions of the dispersibility test where 3-inch square fabric samples are employed.

Example XV

This example shows the use of cellulose esters as the water-sentitive fibers in this invention.

A starting fabric (A) is made by hydraulically entangling a random web (1.03 oz./yd.^{2}) of 0.75-inch long rayon staple of 1.5 d.p.f. by passing on a 24-mesh screen at 6 yards per minute under 3 rows of orifices of Example XIV at pressures of 300, 600 and 700 p.s.i. respectively. It has a dry tensile of 3.9/2.0 lb./in. for machine and cross-direction.

Commercial, nonwoven fabrics made by resin bonding rayon fibers oriented in the machine direction of 0.65 and 1.8 oz./yd.^{2} weight are used as starting fabrics (B) and (C), respectively.

An aqueous solution containing 50% urea and 18% H_3PO_4 and 0.3% of a polysaccharide thickening agent is used to make areas of cellulose phosphate (CP) from the rayon.

A 25% solution succinamic acid in dimethyl formamide is used to make cellulose hemi-succinate (CHS) from the rayon.

An aqueous solution containing 40% urea, 20% sulfamic acid and 0.3% of a thickener is used to make cellulose sulfate (CS) from rayon.

The solution is applied to the starting fabric, lying on blotting paper, from a hypodermic syringe with a No. 26 needle to form lines spaced 0.5 inch apart parallel to the weaker direction of the fabric. The lined fabrics are

placed on a sheet dryer and baked. The baked fabrics are washed in an aqueous solution containing 17% Na_2SO_4 and 3% Na_2HPO_4 adjusted to a pH of about 8–8.5 to convert the cellulose esters to the sodium salt forms (i.e., sodium cellulose phosphate, etc.). The fabrics are squeezed out, blotted between paper towels, and dried on the sheet dryer at 105° C.

Tensile tests are run on 1-inch wide strips cut in the machine direction (i.e., 90° to the lines of chemical modification).

Typical results are given below:

	Fabric	Modification	Baking		Wet tensile (lb./in.)
			Time (min.)	Temp. (° C.)	
Item:					
a	A	CP	0.5	160	0.051
b	A	CHS	5.0	180	0.004
c	A	CS	2.0	150	0.034
d	B	CS	2.0	150	0.031
e	C	CS	4.0	150	0.031

Following the above procedures the nonwoven fabric A is chemically modified along intersecting lines defining 0.5-inch squares and the lines of cellulose ester converted to the salt form and dried. The products have adequate strength to be used as wrappers on sanitary napkins and can be disposed in a toilet.

The above reactions are effective on wood pulp and cotton linters so that fabrics containing blands of rayon fibers and wood pulp can be used to form areas of water-sensitive cellulose derivative fibers.

Products of the invention having discrete areas of water-resistant cellulosic fibers surrounded by areas containing water-sensitive cellulose derivative fibers have been illustrated mainly by square, grid patterns of modified fibers. It may be desirable to use patterns which do not yield straight lines of water-sensitive fibers such as contiguous hexagons, contacting circles of the same or different diameters, offset arrangements of rectangles of the same size having only one common side between adjacent rectangles, and arrangements of rectangles, triangles and other polygons of mixed sizes and combinations of the above.

What is claimed is:

1. An integral fabric having a plurality of discrete areas of water-resistant cellulosic fibers, said areas having a maximum dimension of less than 2 inches each and being surrounded by areas containing at least 50% by weight of water-sensitive cellulose derivative fibers having a degree of substitution of at least 0.2 and comprising up to 90% of the area of the fabric, said fabric having fluids, but disintegrating into flushable pieces upon being subjected to a water stream in a toilet.

2. The fabric of claim **1** wherein the water-resistant celluosic fibers are selected from the group consisting of cellulose fibers having a degree of substitution of less than 0.1, regenerated cellulose fibers having a degree of substitution of less than 0.1 and fibers of the acid form of ethers or esters of cellulose having a degree of substitution of less than about 0.4 and the water-sensitive cellulose derivative fibers are of cellulose derivative selected from the group consisting of monovalent metal salts of carboxyalkyl ethers of cellulose, monovalent metal salts of partial esters of cellulose with an inorganic polybasic acid, and monovalent metal salts of partial esters of cellulose with an organic polybasic acid.

3. A sanitary napkin comprising an absorbent core with a covering of the fabric of claim **1**.

4. A diaper comprising an absorbent core sandwiched between two layers of the fabric of claim **1**.

5. The fabric of claim **1** wherein the water-sensitive cellulose derivative fibers are composed of the sodium salt of carboxymethyl cellulose having a degree of substitution of between 0.2 and 0.8 and the water-resistant areas are rayon.

6. The fabric of claim **1** wherein the areas comprising water-sensitive fibers comprise up to 60% of the fabric.

7. The fabric of claim **1** having a staple, nonwoven construction.

8. An integral nonwoven fabric consisting essentially of fibers aligned primarily in one direction, said fabric having a wet tensile strength of less than 0.1 lb./in. and having a plurality of discrete bands transverse to the direction of fiber alignment, each having a width less than about 0.5 in. and consisting essentially of water-resistant cellulosic fibers, said bands alternating with water-sensitive bands containing at least 50% by weight of cellulose ether or cellulose ester fibers with a degree of substitution of at least 0.2, the area of the water-sensitive portions comprising up to 90% of the total fabric area.

9. The fabric of claim **8** wherein the bands of water-sensitive fibers comprise up to 60% of the fabric.

10. The fabric of claim **8** wherein the water-resistant cellulosic fibers are selected from the group consisting of cellulose fibers having a degree of substitution of less than 0.1, regenerated cellulose fibers having a degree of substitution of less than 0.1 and fibers of the acid form of carboxyalkyl ethers of cellulose having a degree of substitution of less than about 0.4 and the water-sensitive cellulose fibers are of cellulose derivative selected from the group consisting of monovalent metal salts of carboxyalkyl ethers of cellulose, monovalent metal salts of partial esters of cellulose with an inorganic polybasic acid, and monovalent metal salts of partial esters of cellulose with an organic polybasic acid.

11. A sanitary napkin comprising an absorbent core with a covering of the fabric of claim **8**.

12. A diaper comprising an absorbent core sandwiched between two layers of the fabric of claim **8**.

13. A process for preparing a fabric having substantial strength when dry and upon exposure to body fluids, but that disintegrates into flushable pieces upon being subjected to a water stream in a toilet, comprising treating up to 90% of the area of an integral fabric containing at least 50% by weight of regenerated cellulose fibers having a D.S. of less than 0.1 with an aqueous solution containing from about 5% to 30% sodium chloroacetate and from about 2 to 10% of an alkali metal hydroxide and drying the fabric, said treated area surrounding a plurality of discrete untreated areas having a maximum dimension of less than two inches each.

14. A process for preparing a fabric having substantial strength when dried and upon exposure to body fluids, but that disintegrates into flushable pieces upon being subjected to a water stream in a toilet, comprising, treating up to 90% of the area of an integral nonwoven fabric consisting essentially of at least 50% by weight of regenerated cellulose fibers having a D.S. of less than 0.1 and being aligned primarily in one direction, with an aqueous solution containing from about 5% to 30% sodium chloroacetate and from about 2% to 10% of an alkali metal hydroxide and drying the fabric, said treated area being in the form of a plurality of bands transverse to the direction of fiber alignment and alternating with bands of untreated fabric, each having a width less than about 0.5 inch.

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128—290; 8—114.6, 120; 161—170; 28—72; 117—44

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,521,638 Dated July 28, 1970

Inventor(s) Robert Guy Parrish

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 15, line 51, after "having" and before "fluids" insert the following:

-- substantial strength when dry and upon exposure to body --.

Signed and sealed this 20th day of April 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents