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54 **Process for making nonwoven fabrics by bonding organic fibers.**

57 A nonwoven fabric is prepared by simultaneously heating and compressing a nonwoven web of organic fibers which contains a bonding quantity of water as defined in the description. Compressive force and temperature and time of web exposure thereto are correlated to provide a wash stable fabric, but the correlation is such that wash stable bonding of an otherwise dry web is not obtained. A "dry" web is one containing equilibrium water content at 65% relative humidity at 22°C.

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PROCESS FOR MAKING NONWOVEN FABRICS BY
BONDING ORGANIC FIBERS

5 This invention relates to processes for bonding organic fibers. More specifically, the invention relates to such processes wherein water is utilized as an agent for effecting autogenous bonding of fibers constituting nonwoven webs.

10 Nonwoven fabrics and the utilization thereof are well known to those skilled in the art. Such fabrics are prepared by forming a web of continuous filament and/or staple fibers. Such webs, as formed, are generally lacking in physical integrity and readily disintegrate when handled. Therefore, it is customary to increase the integrity of such webs by bonding the fibers constituting the web at fiber crossover points. Fiber bonding has been successfully accomplished by mechanical entanglement of web fibers; application of adhesives; and autogenously by the use of heat or liquid or gaseous agents to soften the fibers and render them cohesive.

20 Autogenous bonding has been found particularly advantageous from the standpoint of providing fabrics of good strength without incorporating an adhesive having a composition differing from that of the fibers in the fabric. In

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autogenous bonding, strength can in some instances be improved and/or decorative fabric patterns or modified tactile properties provided by overall or intermittent compression of the softened fibers. However, certain process difficulties have hitherto been associated with autogenous bonding. For example, in processes employing thermal softening of fibers, careful control of temperature (and pressure, if utilized) is required to obtain adequate bonding without complete melting resulting in destruction of the fibrous structure and/or sticking of the web to supports or pressure applying devices. Techniques using liquid softening agents must similarly be carefully controlled to prevent total web dissolution. Further, many liquid bonding agents and gaseous bonding agents, e.g. HCl, are corrosive to equipment and/or pose potential hazards to operating personnel if carelessly handled.

The bonding of fibrous webs by the application of specified amounts of water followed by compression of the web to prescribed thicknesses at specified temperatures is described in Japanese patent publication Nos. 74-3459; 74-3460; and 74-3461. However, attempts to prepare nonwoven fabrics in accordance with the teachings of the aforesaid Japanese publications have yielded materials which failed to satisfactorily withstand conventional usage such as washing.

A practical process utilizing water as an agent for bonding organic fibers to form fabrics of acceptable physical properties would represent a substantial advance in the art.

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SUMMARY OF THE INVENTION

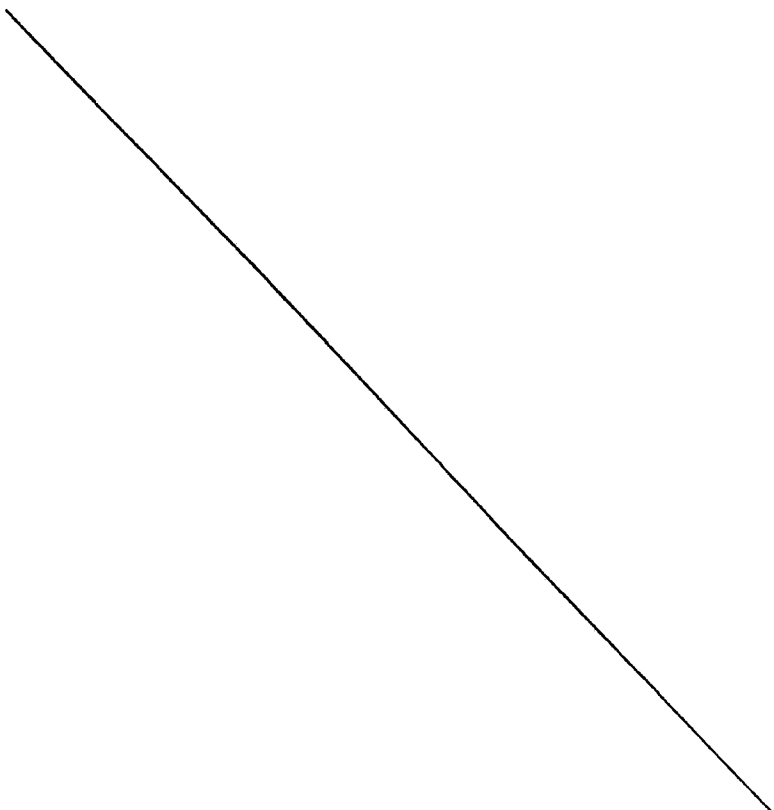
The process of the invention is one for making nonwoven fabrics, and is characterised by simultaneously compressing and heating a nonwoven web 5 of water bondable organic fibers, said web containing a bonding quantity of water; the compressive force, temperature, and time of exposure of the web thereto being correlated to effect autogenous fiber bonding sufficient to provide a wash-stable fabric 10 but the correlation being such as not to effect autogenous bonding of fibers of an otherwise equivalent dry web sufficient to provide a wash-stable fabric.

A preferred process according to the 15 invention is characterised by providing a bonding quantity of water in a nonwoven web of water bondable organic fibers and passing said web containing said water through and compressing said web in the nip of a pair of rolls at least one of which is 20 heated; the compressive force, the roll temperature, and the rate of passage of the web through the nip being correlated to effect autogenous fiber bonding sufficient to provide a wash-stable fabric but the correlation being such as not to effect autogenous 25 bonding of fibers of an otherwise equivalent dry web to provide a wash-stable fabric.

A further preferred process according to the invention is characterised by providing a bonding quantity of water in a nonwoven web of nylon 30 6,6 continuous filament fibers; passing said web containing said water through and compressing said web in the nip of a pair of rolls at least one of which is heated and at least one of which is patterned to compress the web in spaced, discrete areas; the

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compressive force, roll temperature and rate of
passage of the web through the nip being correlated
to effect bonding in the spaced, discrete areas
compressed sufficient to provide a wash-stable
5 fabric but the correlation being such as not to effect
bonding of fibers of an otherwise equivalent dry web
sufficient to provide a wash-stable fabric. The
practice of the invention will be understood from
the following description of the preferred embodi-
10 ments.



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DESCRIPTION OF THE PREFERRED EMBODIMENTS

The process of this invention can be utilized to effect bonding of any water bondable fibers. The term "water bondable fibers" denotes any fibers which, in the form of a web containing a bonding quantity of water, can be bonded to form a wash stable fabric (a fabric exhibiting little or no pilling when subjected to a hereinafter described washing test) under a combination of compressive force, temperature and exposure time which will not effect such bonding in an otherwise identical dry web. Examples of water bondable fibers suitable for processing in accordance with this invention include fibers derived from: polyhexamethylene adipamide, polycaproamide and other polyamides, acrylic and modacrylic polymers and copolymers and mixtures and blends thereof. Polyamide polymer fibers, e.g. nylon 6,6, are particularly well suited for the practice of this invention. Composite fibers, including those having components which are not, alone, water bondable can be utilized. For example a fiber having a nylon sheath and a polyester core or side-by-side bicomponent fibers or other multicomponent fibers having bondable surface portions can be utilized. The fibers can be in the form of continuous filament or staple and, if desired, can be crimped or textured to provide elasticity or other desired characteristics to the finished fabric.

The water bondable fibers are processed in the form of nonwoven webs. Such webs of bondable fibers can consist solely of water bondable fibers or can also contain other synthetic or natural fibers which are not bondable. The manner of web formation is not critical. Generally webs are formed by deposition of fibers on a moving belt in either random or aligned orientation to provide a web having a weight 4 to 400 grams per square meter, preferably 10 to 250 grams per square meter. A particularly useful method of web formation is disclosed in United States Patent No. 3,452,615

5 In practicing this invention, a bonding quantity of
water is applied to the nonwoven web. By "bonding quantity"
of water is meant a quantity such that subsequent compression
of the web at elevated temperature effects fiber bonding
adequate to provide a wash-stable fabric. The minimum
10 quantity of water required will vary somewhat depending on
fiber composition, web structure, fiber denier, and bonding
conditions. The maximum quantity usable is governed primarily
by practical consideration of techniques available for water
application and ability of the web to retain the water
15 applied. In general, bonding will be adversely affected by
inadequate water but the use of excess water presents no
problems other than those associated with processing conven-
ience and economics. Therefore, in practice, relatively large
amounts of water (consistent with convenience of application
and handling) will be applied to the web to ensure adequate
20 bonding. Optimum amounts from the standpoint of bonding
efficiency, processing convenience and economics can readily
be determined by routine testing.

 The bonding quantity of water can be applied to the
25 web by a variety of techniques. For example, the web can be
immersed in water by passing the web supported on a moving
belt or similar means through a tray of water or under spray
nozzles. Humid atmospheres, mist chambers, wet rolls, etc.
can also be employed to provide or facilitate obtaining a
30 web containing the desired bonding quantity of water.

 The web containing a bonding quantity of water is
then simultaneously compressed and heated. Simultaneous com-
pression and heating can be conveniently accomplished using a
pair of mechanical compressive means such as plattens or rolls
35 with one or both of the compression means being heated. Pref-
erably the wetted web is compressed in the nip of a pair of
rotating rolls at least one of the rolls being heated. It is
further found that when the rolls are adapted (e.g. via
bosses or land and groove patterns) to compress the fabrics
40 in spaced, discrete areas, fabrics having particularly desir-
able tactile properties in terms of drape can be obtained.

The compressive force, temperature, and the duration of web exposure to such force and temperature must be correlated to effect fiber bonding sufficient to yield a wash-stable fabric. However, the correlation is such that application of these processing conditions to an otherwise equivalent dry web does not provide a wash-stable fabric. The term "dry" is used to denote a web containing equilibrium water content at 65% relative humidity at 22°C. A completely anhydrous web will, of course, also fail to yield wash-stable fabrics under such conditions. However, the foregoing definition of the term "dry" is chosen to facilitate testing without necessity of rendering the samples anhydrous.

Since practice of the invention requires a correlation of conditions such that wash-stable bonds are not obtained with dry webs, the roll or other pressing means will generally be heated to a temperature less than the fiber melting point (as determined for anhydrous fibers at atmospheric pressure). Generally, the temperature will be at least 100°C. and no less than 100°C. below the fiber melting point. At lower temperatures, effective bonding is generally not obtained in reasonable time regardless of the compressive force utilized. Optimum temperatures (correlated with selected pressures) for various fibers can be determined by routine tests. For example, temperatures in the range 150°C.-250°C. are generally satisfactory for bonding nylon 6,6; temperatures in the range 150°C.-250°C. are also generally satisfactory for bonding acrylic fibers.

Regardless of the temperature chosen, satisfactory bonding will not take place in the absence of adequate compression. Although the mechanism of the bonding process is not fully understood, it is believed that application of sufficient pressure, in addition to ensuring fiber to fiber contact, results in a gasketing or sealing effect retaining water under the pressure point as heat is transferred to the compressed wetted web. Thus, it is believed that the water is heated above its atmospheric boiling point and that the superheated water (or steam) under pressure participates in the bonding mechanism.

The duration of time in which the web is subjected to heating and compression can be regulated by conventional techniques, e.g. regulation of roll speed. Such time will be chosen to permit adequate heating of the web to effect bonding. In general, the use of higher temperatures lowers the exposure time required.

As previously indicated, it is not necessary that the overall web be compressed and heated. Excellent results are obtained by compressing and heating the web in a pattern defined by compressed (bonded) and uncompressed (unbonded) areas or in spaced discrete locations, for example, by use of bossed or engraved rolls or rolls having land and groove designs adapted to compress the web in such spaced, discrete locations. When using such techniques, it is generally desired that the web be substantially uncompact prior to pressing. In order to provide adequate overall physical properties from 2% to 80%, preferably 3% to 50%, of the total surface area of the web should be subjected to compression and heating. When providing discrete, spaced bond sites, the number of bond sites per square centimeter should be from 1 to 250, preferably 16 to 64 in order to provide desired physical properties.

In some instances, various adhesion promoters can be used in conjunction with water to provide bonds of improved physical properties or permit use of somewhat lower temperatures and/or pressures. In such instances (consistent with definitions previously set forth) the bonding quantity of water and the correlated compressive force and temperature will be such that wash-stable fabrics are obtained even in the absence of the adhesion promoter but such that wash-stable fabrics are not obtained in the absence of such bonding quantity of water. That is, the amount of adhesion promoter utilized will not, alone, effect wash-stable bonding of a dry web. Suitable adhesion promoters include substances which form aqueous mixtures or solutions and/or which tend to facilitate rendering the fibers autogenously cohesive. For example, suitable adhesion promoters for nylon webs include inorganic and organic materials such as hydrochloric acid,

sulfuric acid, formic acid, phenol, resorcinol, methanol, athanol, etc. Reducing acids such as hydrochloric acid appear preferable to oxidizing acids because such acids have less tendency to effect polymer degradation. Aqueous solutions of inorganic salts such as sodium iodides, calcium bromides, zinc chloride or magnesium chloride can also be used. Examples of suitable adhesion promoters for acrylonitrile polymer webs include ethylene carbonate, propylene carbonate, dimethylformamide, dimethylacetamide, chloral hydrate, tetrahydrothiophene-1,1-dioxide, butyralacetone and salts such as sodium thiocyanate, lithium iodide, calcium bromide, zinc chloride and magnesium chloride.

The following examples will facilitate a better understanding of the invention and the desirable properties of fabrics produced thereby. The tests described below are used to determine fabric properties as reported in the examples or otherwise referred to in the specification and claims:

Wash Stability

Wash stability is determined as follows: Nonwoven fabric samples are mixed with at least 10 pieces of hemmed cotton sheeting each measuring about 91 cm x 91 cm. The number and size of the nonwoven fabric samples are subject to the following constraints:

1. Total area of the nonwoven samples is less than 6.5 m².
2. Each sample is at least 465 cm² in area with a minimum dimension of 15 cm.
3. No sample is larger than 0.929 m² in area or more than 0.305 m in its maximum dimension.

In addition, the total weight of the cotton sheeting plus the nonwoven samples should not exceed about 1.8 kg. (These constraints assure comparable results.)

The load is washed in a Kenmore Model 76431100 washing machine (marketed by Sears Roebuck & Co.) using the "normal" cycle (14 min.) "Hi" water level (55 ℓ), HOT WASH, WARM RINSE (water temperatures of 60°C. ± 3°, 49°C. ± 3°) and 90 g of American Association of Textile Colorists and Chemists Standard Detergent 124.

The wash load is then dried in a Kenmore electric dryer, Model 6308603 (marketed by Sears, Roebuck and Co.) for at least 30 minutes (or longer if required to dry the entire load). The test specimens are then evaluated by visual
5 observation to determine the number of pills formed. A pill is a visually discernible (usually roughly spherical) tangle of fiber, or fiber plus extraneous material, extending above the surface of a fabric and connected to the body of the fabric by one or more filaments. A fabric is considered to
10 fail the test when 5 or more pills are observed in any 929 square centimeters surface area or when more severe physical deterioration is visually discernible. Fabrics passing the above test are considered "wash-stable". In the test described, the pills are predominantly formed by fibers which
15 were not bonded in the process or which, in test procedure, were freed from bond sites. Thus the degree of pilling provides a measure of the efficacy of the process for forming bonds and a measure of the resulting bond integrity. In instances of very poor bonding more severe fabric deviation
20 than pilling, e.g. complete disintegration, may be observed. As a practical matter, fabrics which do not pass the test (even if not totally or partially disintegrated in the test) will not withstand substantial physical stress or repeated washings with excessive deterioration.

25 Other tests reported in the examples provide an indication of various properties of general interest which are obtained in fabrics produced by the practice of this invention and indicate the general effect of variations in process conditions on these properties.

30 Evaluation of Physical Properties

Breaking Load and Elongation are determined by American Society of Testing Materials (ASTM) procedure D-1682-64.

35 Bending Length is determined by ASTM procedure D-1388-64.

Trapezoid Tear Strength is determined by ASTM procedure D-2263-68.

Strip Tenacity is determined by dividing the breaking load of a cut strip by the strip basis weight and is expressed as g/cm/g/m^2 .

For webs that are bonded using an embossed roll the bond sites are evaluated microscopically by examining both sides of the web with a stereo microscope and physically by subjecting the web to a tensile stress. The size of the bond on each side is measured and compared to the size of the boss portion of the embossed roll. Desirable bond sites are those wherein the bond is the same size on both sides of the web and also approaches the size of the boss portion. To measure bonding between fibers within the bond sites, a dissecting needle is scratched along the bond while the sample is examined microscopically. This procedure can indicate how firmly filaments are held together within the bond site. Samples, approximately 2.54 cm square, are slowly stretched in an extensometer and the fibers are observed within the bond sites. The location of fiber failure is an indication of fiber fusion within the bond site.

The bond sites are rated on a scale from 0 to 5. An explanation and description of the ratings is as follows:

	<u>Bond Rating</u>	<u>Bond Description</u>
	0	- No significant bonding.
25	1	- Adhering fibers separate readily under tension applied to strip.
	2	- Adhering fibers separate under tension applied to strip, appreciable force required.
30	3	- Part of the adhering fibers separate under tension, part break outside the bonded section.
	4	- Most of the fibers break outside bond site under applied tension, fibers can still be picked or teased out of bond site.
35	5	- Fibers well fused, cannot be picked out of bond site.

Bond RatingBond Description

5+ - Fused bond site tends to split under tension.

5 Fabrics having a bond rating of 3 or greater are generally wash-stable.

In the examples the term "press pressure" refers to the positive force, expressed in kilograms per linear centimeter, compressing the rolls together. This force includes mechanical pressure utilized to compress the rolls, together with the compressive effect attributable to the weight of the rolls. In the case of bossed rolls, it is assumed for purposes of calculation, that all of the pressure is exerted at the boss points and a "corrected pressure" is calculated accordingly.

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EXAMPLE I

A series of nonwoven webs of nylon 6,6 continuous spun fibers were prepared. These webs were then sandwiched between two fiber glass screens and immersed in water at room temperature. Excess water was removed so that about 20-30 percent by weight of the uncompact web weight remained. The water wetted webs were then pressed at 9.1 meters/min. under a pressure of 17.4 kg/linear cm in either of two modes. In one mode the two press rolls consisted of a smooth resilient rubber roll at 40°C., and a smooth metallic roll heated to various temperatures as shown in Table I. In the second mode a rubber roll was used with a heated embossed metallic roll. The embossed roll had 48 square boss sites/cm² which were aligned in a square pattern and covering about 15 percent of the surface area of the roll. When correcting for the 15% pattern coverage (assuming all pressure is applied to only the boss sites), the corrected pressure at the roll nip was 115.9 kg/cm. Embossed roll temperatures are shown in Table I. The results of tests performed in accordance with the procedures herein described on the bonded fabrics obtained from these webs are reported in Table I, below.

TABLE I
Effect of Water, Heat and Bonding Mode in Bonding Nonwoven Nylon Webs

Web Sample No.	Heated Roll Mode		Web Basis Weight g/m ²	Bonding Length, cm	Strip Tenacity g/cm/g/m ²	Strip Elongation %	Trapezoidal Tear g/g/m ²	Bond Rating Top(3)/Bottom
		Temp. °C						
1	Bossed (1)	150	33.9	-	7.8	14	-	1/1
2	"	160	33.9	-	14.6	25	-	1/1
3	"	170	33.9	1.55	19.9	34	-	2/2
4	"	180	30.5	1.78	28.2	40	-	5/4
5	"	190	33.9	1.57	32.4	45	99.2	5+/5+
6	Smooth (2)	135	33.9	1.73	3.7	7	-	1/1
7	"	150	37.3	1.73	4.2	23	-	1/1
8	"	160	37.3	1.78	5.2	29	-	1/1
9	"	170	33.9	1.98	8.4	50	104.5	2/2
10	"	180	30.5	2.26	24.6	21	53.6	3/2

(1) Corrected pressure 115.9 kg/cm. (Press Pressure x $\frac{\text{Total Roll Surface Area}}{\text{Total Area of Boss Sites}}$)

(2) Press Pressure 17.4 kg/cm.

(3) Top indicates side of web facing heated metallic roll.

These data show that pressing the wetted web with a heated embossed roll at 170°C. began to develop a significant bonding level. When the temperature of the embossed roll was increased to 190°C., the combined action of water and pressure yielded a bonded fabric with excellent properties. The webs pressed overall which were prepared at the lower pressure did not compare in properties until the press temperature was increased to 180°C.

EXAMPLE II

The purpose of this example is to measure the effect of bonding webs that have absorbed lower quantities of water than the webs of Example I. The moisture was sorbed by long exposures to moist air at 65 and 98% R.H. Similar fibers were used and the process conditions of Example I are the same. All of the webs were pressed with a heated embossed roll having the same pattern as the roll described in Example I. Details of tests performed on the bonded fabrics obtained from these webs appear in Table II.

These data show that webs containing 4 and 8 percent water add-on required significantly higher temperatures to achieve desirable physical properties. These webs did not attain properties comparable to webs containing higher quantities of water add-on. The webs that absorbed 4 percent water did not attain good bond ratings even when the roll temperature was at its highest level.

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TABLE II
Effect of Percent Water Add-On and Heat in Bonding Nonwoven Nylon Webs

Web Sample No.	% Water (2)	Heated Roll Temp. °C.	Web Basis Weight g/m ²	Bending Length cm	Strip Tenacity g/cm/g/m ²	Strip Elongation %	Bond Rating Top(1)/Bottom
1	4	150	30.8	-	3.7	18	1/1
2	4	160	32.2	-	4.2	20	1/1
3	4	180	32.2	1.75	4.2	10	1/1
4	4	190	31.2	1.78	6.8	12	2/1
5	4	200	32.5	1.88	11.5	20	2/1
6	8	150	31.5	1.88	3.7	6	1/1
7	8	160	32.5	1.85	4.7	6	1/1
8	8	170	32.5	1.98	6.3	8	1/1
9	8	180	31.5	2.01	8.9	11	2/1
10	8	190	32.5	1.98	14.1	32	2/1
11	8	200	31.5	1.55	23.0	28	5+/5

(1) Top indicates side of web facing heated metallic roll.

(2) As a percent of anhydrous weight.

EXAMPLE III

In this example a series of nonwoven webs of nylon 6,6 continuous spun fibers were prepared. These webs were then wetted with water by spraying. Water was applied to one side of the web with a pneumatic atomizing nozzle having a flat spray. The nozzle, housed in a Plexiglass chamber, was mounted over a moving belt that transported the uncompacted webs through the spray. The amount of water deposited onto the web was varied by changing air pressure, rate of water feed to the nozzle and varying belt speed. The amount applied to the webs varied from 20 to 94 percent add-on by weight (based on the anhydrous web). The wet webs were pressed at 9.1 m/min. between a hard rubber roll at 40°C. and an embossed roll heated to temperatures shown on Table III. The embossed roll had 28 square boss sites/cm², which were aligned in a square pattern. The pattern covered about 18 percent of the fabric area. Sample 1 was pressed with 16.7 kg/linear corrected pressure and the remaining samples were pressed with 252.5 kg/linear cm corrected pressure to insure better heat transfer and good abrasion resistance for both sides of the bonded web. As web basis weight increased, higher press roll temperatures were required because of the increased mass of fiber and water. Details of tests performed on the bonded fabrics obtained from these webs appear in Table III.

These data show that good strength properties can be obtained from webs wetted with 18 to 94 percent by weight of water and heat pressed at 190° to 200°C. When the water is applied to one side of a web by means of an atomizing spray, an add-on of 30 to 80 percent is preferred to ensure uniform bonding throughout the web thickness.

TABLE III
Effect of Water and Mechanical Pressure in Bonding Nonwoven Nylon Webs Using an Embossed Roll

Web Sample No.	Corrected Pressure Kg/cm	Heated Roll Temp., °C.	% Water Add-On	Web Basis Weight g/m ²	Bending Length cm	Strip Tenacity g/cm/g/m ²	Strip Elongation % (1)	Trapezoidal Tear g/g/m ²	Bond (2) Rating Top/Bot.
1	96.7	190	50	29.5	1.32	39.2	47	(4)	5+/4
2	252.5	190	20	33.2	2.36	28.2	24	59.0	5+/5
3	252.5	190	48	34.6	2.13	23.5	28	59.0	5+/5+
4 (3)	252.5	190	63	35.3	2.44	27.2	22	46.9	(4)
5	252.5	190	78	35.3	2.11	22.0	28	44.2	5/5
6	252.5	200	45	37.3	2.13	39.2	46	100.5	5+/5+
7	252.5	200	18	49.5	3.12	49.1	42	85.8	4/3
8	252.5	200	30	50.2	2.84	42.3	36	89.8	5+/3
9	252.5	200	37	48.8	3.20	34.5	23	53.6	(4)
10	252.5	200	64	51.2	2.64	34.5	31	72.4	5+/5+
11	252.5	200	94	50.9	2.82	36.1	40	92.5	5+/5

(1) Strip tenacity, % elongation and trapezoidal tear determined in machine direction.

(2) Top identified as side of web facing heated embossed roll.

(3) Web tended to stick to heated embossed roll.

(4) Not tested

EXAMPLE IV

In this example, a series of nonwoven webs of fibers composed of a 50 percent nylon 6,6 sheath and a 50 percent polyester core were prepared. The webs were treated in accordance with the conditions set forth in Example III. A corrected pressure of 252.5 kg/cm was used for all the web samples. Details of tests performed on the bonded fabrics obtained from these webs appear in Table IV.

These data show that good strength properties were obtained from the webs wetted with 16 to 108 percent by weight of water and heat pressed at 175° to 180°C. This example shows the applicability of this invention for webs composed of fiber of two different polymers wherein one of the polymers is water bondable.

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TABLE IV
 Effect of Water and Mechanical Pressure in Bonding Nonwoven
 Nylon-Polyester Sheath Core Webs Using an Embossed Roll

Web Sample No.	Heated Roll Temp. °C.	% Water Add-On	Web Basis Wt. g/m ²	Bending Length cm	Strip Tenacity ² G/cm/g/m	Strip Elongation %	Trapezoidal Tear ⁽¹⁾ g/g/m ²	Bond Rating Top/Bot.
1	175	16	37.6	2.21	34.5	59	105.9	4/4
2	180	20	34.2	2.06	32.4	64	83.1	5/4
3	180	20	38.6	2.36	39.2	66	100.5	5/4
4	180	50	37.6	2.03	30.3	52	84.4	5/5
5	180	60	39.0	2.36	38.2	72	104.5	(3)
6	180	90	39.0	2.13	34.5	61	84.4	5/5
7	180	108	40.0	2.06	32.4	62	84.4	5/4

(1) Strip tenacity, % elongation and trapezoidal tear determined in transverse direction.

(2) Top identified as side of web facing heated embossed roll.

(3) Not tested.

EXAMPLE V

In this example a 44.1 g/m² nonwoven web of acrylic stable fibers was prepared. The web was sprayed with water using a hand-held spray apparatus with an atomizing nozzle. 5 The wetted web was then pressed at 357.2 kg/linear cm corrected pressure between a smooth resilient rubber roll at 40°C. and a smooth metallic roll heated to 185°C. The web speed through the rolls was 10.7 m/min., bending length of the bonded fabric was 3.48 cm and the strip tenacity was, 18.3 10 g/cm/g/m².

EXAMPLE VI

Nonwoven webs comprised of 3 denier per filament continuous filament nylon 6,6 and having a weight of 34 gms/m² were processed by passing the web through the nip of a pair 15 of heated steel rolls at a speed of 3.9 meters per minute. One of the rolls carried bosses, the tips of which defined a pattern of rectangles (having sides measuring 1.65 and .71 mm) and rhomboids (having sides measuring 1.65 mm and .65 mm) alternating in axial and circumferential rows. The longer 20 dimensions of the rectangle were circumferentially oriented and longer dimensions of the rhomboids were axially oriented. The rhomboids and rectangles were positioned such that extensions of their longitudinal center lines bisect the adjacent parallelograms. Circumferentially, the parallelograms are 25 spaced by a distance of 1.36 mm. Axially, the rectangles are spaced .67 mm. from the acute apexes of the rhomboid and 1.12 mm. from the obtuse apexes. The inclination (position of acute and obtuse apexes) of the rhomboids is reversed in successive axial rows. The bossed roll had about 19 bosses 30 per cm², covering about 21.2% of the roll surface. The remaining roll had a smooth surface. The rolls each had diameters of about 12.7 cm. and both rolls were maintained at 180°C. The rolls were either set at the fixed spacings indicated in Table V below or positive roll pressure was 35 applied as indicated. Prior to passage through the rolls, water was added to certain webs as indicated. The samples of fabric produced were tested for wash-stability and the results are reported in the table.

TABLE V

Test No.	Fixed Roll Spacing (in microns)	Corrected Pressure* (kg/linear cm)	Water Added (% of Original Web Wt.)	Results of Wash Stability Test
1	53	-	none added	Not wash-stable; sample disintegrated
2	78	-	none added	Not wash-stable; sample disintegrated
3	-	94.8	none added	Not wash-stable; sample disintegrated
4	-	154.0	none added	Not wash-stable; sample disintegrated
5	-	213.3	none added	Not wash-stable
6	53	-	15	Not wash-stable
7	78	-	15	Not wash-stable
8	-	94.8	15	Not wash-stable
9	-	154.0	15	Wash-stable
10	-	213.3	15	Wash-stable
11	53	-	25	Not wash-stable
12	78	-	25	Not wash-stable
13	-	94.8	25	Wash-stable
14	-	154.0	25	Wash-stable
15	-	213.3	25	Wash-stable

*Press pressure corrected for 21.2% bond site coverage.

(The fixed roll spacings of 53 microns and 78 microns correspond, respectively, to about 30% and 40% of the thickness of the web compacted at 1 kg/cm^2 to remove bulk. Thus, some web compression was effected in the roll nip.)

The foregoing results further illustrate the criticality of utilizing adequate compressive force correlated with temperature in the practice of this invention. In conjunction with the foregoing tests, identical samples were also subjected to tensile stress and inspected to determine if fibers were pulled from the bond points. It was noted that the samples in which fibers were readily pulled from the bond points were not found to be wash-stable.

EXAMPLE VII

Nonwoven webs comprised of 3 denier per filament continuous filament nylon 6,6 and having a weight of 68 gms/m² were processed in the manner described in Example VI above. Process conditions and results obtained are shown in Table VI below.

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TABLE VI

Test No.	Fixed Roll Spacing (microns)	Corrected Pressure (kg/linear cm)	Water Added (% of Original Web Wt.)	Results of Wash Stability Test
1	99	-	none added	Not wash-stable; sample disintegrated
2	145	-	none added	Not wash-stable; sample disintegrated
3	99	-	15	Not wash-stable
4	145	-	15	Not wash-stable; sample disintegrated
5	99	-	25	Not wash-stable
6	145	-	25	Not wash-stable; sample disintegrated
7	-	94.8	25	Wash-stable
8	-	154.0	25	Wash-stable
9	-	213.3	25	Wash-stable

(The fixed roll spacings of 99 microns and 145 microns correspond, respectively, to about 30% and 40% of the thickness of the web compacted at 41 kg/cm² to remove bulk.)

EXAMPLE VIII

Nonwoven webs comprised of 3 denier per filament nylon 6 staple fibers (5 cm length) and having the weights indicated in Table VII below were processed in the manner described in Example VI above utilizing roll temperatures and other process conditions as shown in Table VII. Test results are shown in the table.

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TABLE VII

Sample No.	Weight ₂ (gms/m ²)	Fixed Roll Spacing (microns)	Corrected Pressure (kg/linear cm)	Water Added (% of Original Web Wt.)	Roll Temp. °C.	Results of Wash Stability Test
1	50.8	53	-	none added	180	Not wash-stable; disintegrated
2	50.8	53	-	15	180	Not wash-stable
3	50.8	53	-	25	180	Not wash-stable
4	50.8	-	213.3	none added	180	Not wash-stable
5	50.8	-	213.3	15	180	Wash-stable
6	50.8	53	-	none added	135	Not wash-stable; disintegrated
7	50.8	53	-	15	135	Not wash-stable; disintegrated
8	50.8	53	-	25	135	Not wash-stable; disintegrated
9	50.8	-	213.3	none added	135	Not wash-stable; disintegrated
10	50.8	-	213.3	15	135	Not wash-stable
11	50.8	-	213.3	25	135	Not wash-stable
12	101.7	104	-	none added	180	Not wash-stable; disintegrated
13	101.7	104	-	15	180	Not wash-stable
14	101.7	104	-	25	180	Not wash-stable; disintegrated
15	101.7	-	213.3	none added	180	Not wash-stable
16	101.7	-	213.3	15	180	Wash-stable
17	101.7	-	213.3	25	180	Wash-stable

(The fixed roll spacings correspond to about 30% of the thickness of the web compacted at 41 kg/cm² to remove bulk.)

The foregoing data further demonstrate that proper correlation of compressive force and temperature is critical in obtaining fabrics of acceptable properties.

By reference to the foregoing description and
5 examples, those skilled in the art can practice the process of the invention within the scope of the appended claims to obtain a variety of nonwoven fabrics useful as substitutes for conventional knitted and woven fabrics and in other well understood applications of nonwoven fabrics.

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5 What is claimed is:

1. A process for making nonwoven fabrics, said process being characterized by simultaneously compressing and heating a nonwoven web of water bondable organic fibers, said web containing a bonding quantity of water; the
10 compressive force, temperature, and time of exposure of the web thereto being correlated to effect autogenous fiber bonding sufficient to provide a wash-stable fabric but the correlation being such as not to effect autogenous bonding of fibers of an otherwise equivalent dry web sufficient to
15 provide a wash-stable fabric.

2. The process of claim 1 wherein said web containing a bonding quantity of water additionally contains an adhesion promoter.

3. The process of claim 1, wherein said water
20 bondable fibers are nylon 6,6 fibers.

4. The process of claim 1 wherein the web is heated by contact with compression means maintained at a temperature above 100°C. and below the fiber melting point as measured by anhydrous fibers at atmospheric pressure, but
25 no more than 100°C. below such fiber melting point.

5. The process of claim 1 wherein the web has a dry weight of from 10 to 250 grams per square meter.

6. A process for making nonwoven fabrics, said process being characterized by providing a bonding quantity
30 of water in a nonwoven web of water bondable organic fibers and passing said web containing said water through and compressing said web in the nip of a pair of rolls at least one of which is heated; the compressive force, the roll temperature, and the rate of passage of the web through the
35 nip being correlated to effect autogenous fiber bonding sufficient to provide a wash-stable fabric but the correlation being such as not to effect autogenous bonding of fibers of an otherwise equivalent dry web to provide a wash-stable fabric.

7. The process of claim 6 wherein at least one of said rolls bears a patterned surface adapted to compress the web in spaced, discrete areas and provide a fabric having a pattern of from 16 to 64 discrete bond sites per square
5 centimeter covering from 3% to 50% of the fabric surface area.

8. A process for making a nonwoven fabric said process being characterized by providing a bonding quantity of water in a nonwoven web of nylon 6,6 continuous filament fibers; passing said web containing said water through and
10 compressing said web in the nip of a pair of rolls at least one of which is heated and at least one of which is patterned to compress the web in spaced, discrete areas; the compressive force, roll temperature and rate of passage of the web through the nip being correlated to effect bonding in the spaced,
15 discrete areas compressed sufficient to provide a wash-stable fabric but the correlation being such as not to effect bonding of fibers of an otherwise equivalent dry web sufficient to provide a wash-stable fabric.

9. The process of claim 8 wherein the roll
20 temperature is below the fiber melting point but no more than 100°C. below the fiber melting point.

10. The process of claim 9 wherein the web has a dry weight of from 10 to 250 grams per meter.

11. The process of claim 10 wherein the patterned
25 roll has a pattern of bond sites disposed to provide a fabric having a pattern of from 16 to 64 spaced, discrete bond sites per square centimeter, said bond sites covering from 3% to 50% of the fabric surface area.

12. The process of claim 10 wherein each roll has a
30 land and groove pattern interacting with the land and groove pattern of the other roll to provide a fabric having a pattern of from 16 to 64 spaced, discrete bond sites per square centimeter, said bond sites covering from 3% to 50% of the fabric surface area.



DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. '79)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	FR - A - 2 348 301 (MONSANTO) * Page 7, lines 1-6; claims 1-3, 5-8, 10, 13 *	1-12	D 04 H 1/54 3/14

	FR - A - 2 299 437 (JAPAN VILENE) * Claims 3-6 *	1, 2, 4-6, 10	

	FR - A - 2 110 346 (BAYER) * Page 5, lines 15-18; example 1; claims 1, 2, 4, 5, 7 *	1-6, 9, 10	

	US - A - 3 365 354 (P.N. BRITTON) * Column 3, lines 5-12, 17-21; claims 1-11 *	1, 2, 4	D 04 H 1/54 3/14

	DE - A - 2 056 542 (FIRET) * Page 9, lines 36-40; page 10, lines 1-4; claims 1-4, 13, 22, 24 *	1-4	

	GB - A - 618 178 (BRITISH CELANESE) * Claim 1 *	1	

<p><input checked="" type="checkbox"/> The present search report has been drawn up for all claims</p>			TECHNICAL FIELDS SEARCHED (Int. Cl. '79) CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons &: member of the same patent family, corresponding document
Place of search	Date of completion of the search	Examiner	
The Hague	07-03-1980	ELSEN-DROUOT	