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(54) **ELASTOMERIC SPUN BONDED FABRIC OF POLYPROPYLENE AND PROCESS FOR MAKING**

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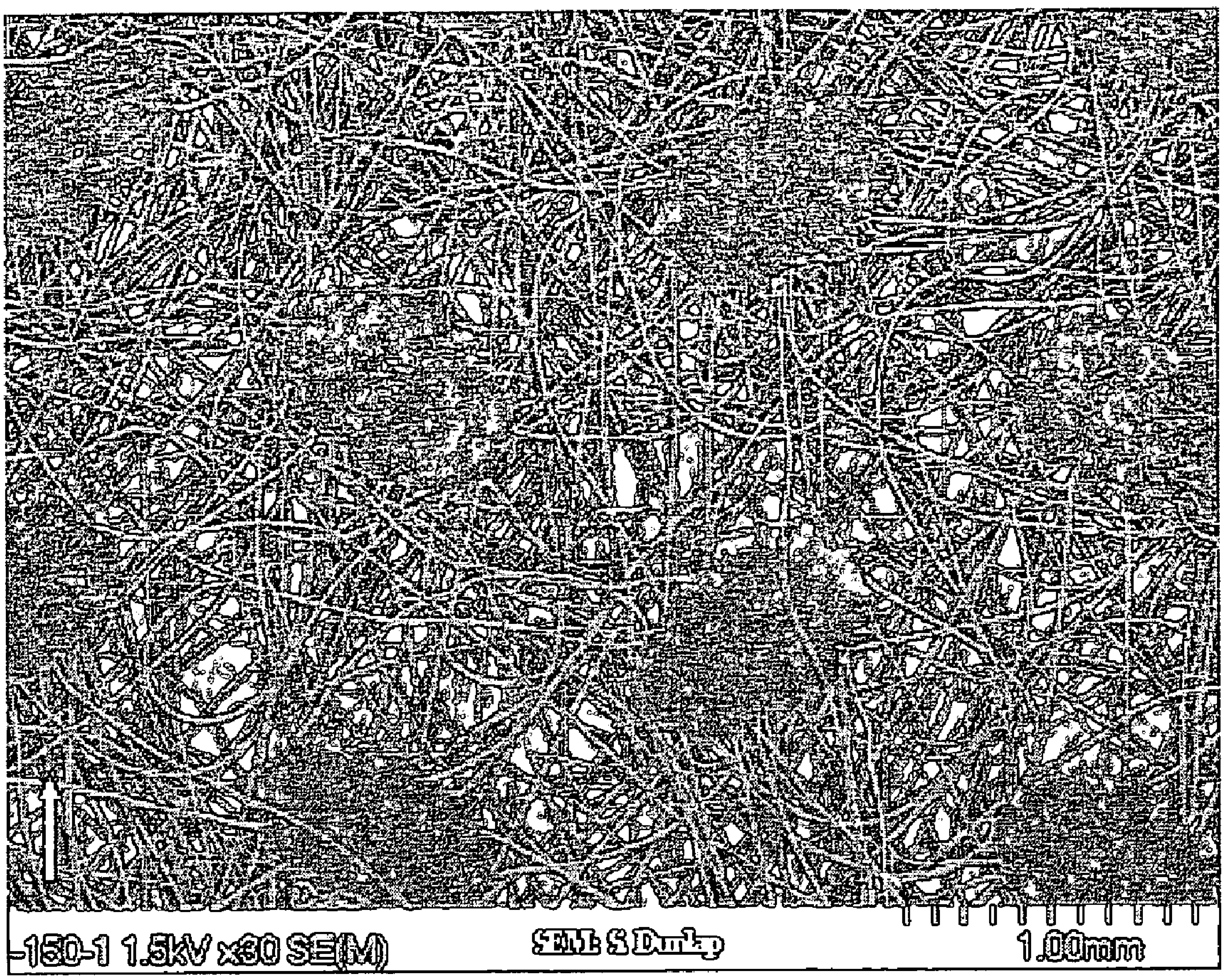
(57) **ABSTRACT**

The present invention provides for a non-woven fabric composite consisting essentially of a mutually interbonded mixture of crimped isotactic polypropylene fiber segments and uncrimped hard elastic isotactic polypropylene fiber segments. A process to manufacture the non-woven fabric composite and textile goods fabricated from the disclosed non-woven fabric composite are also provided.



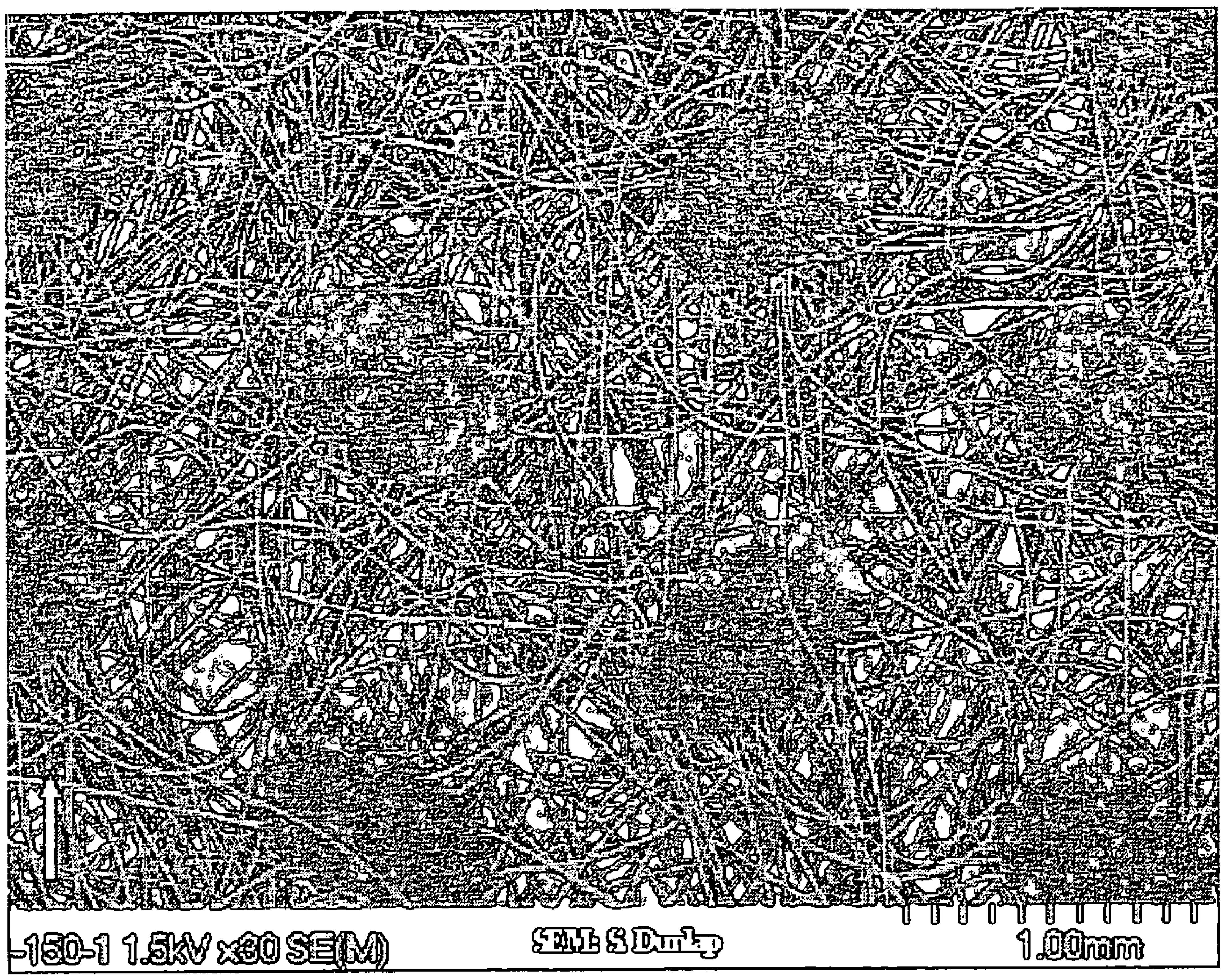


FIG. 1

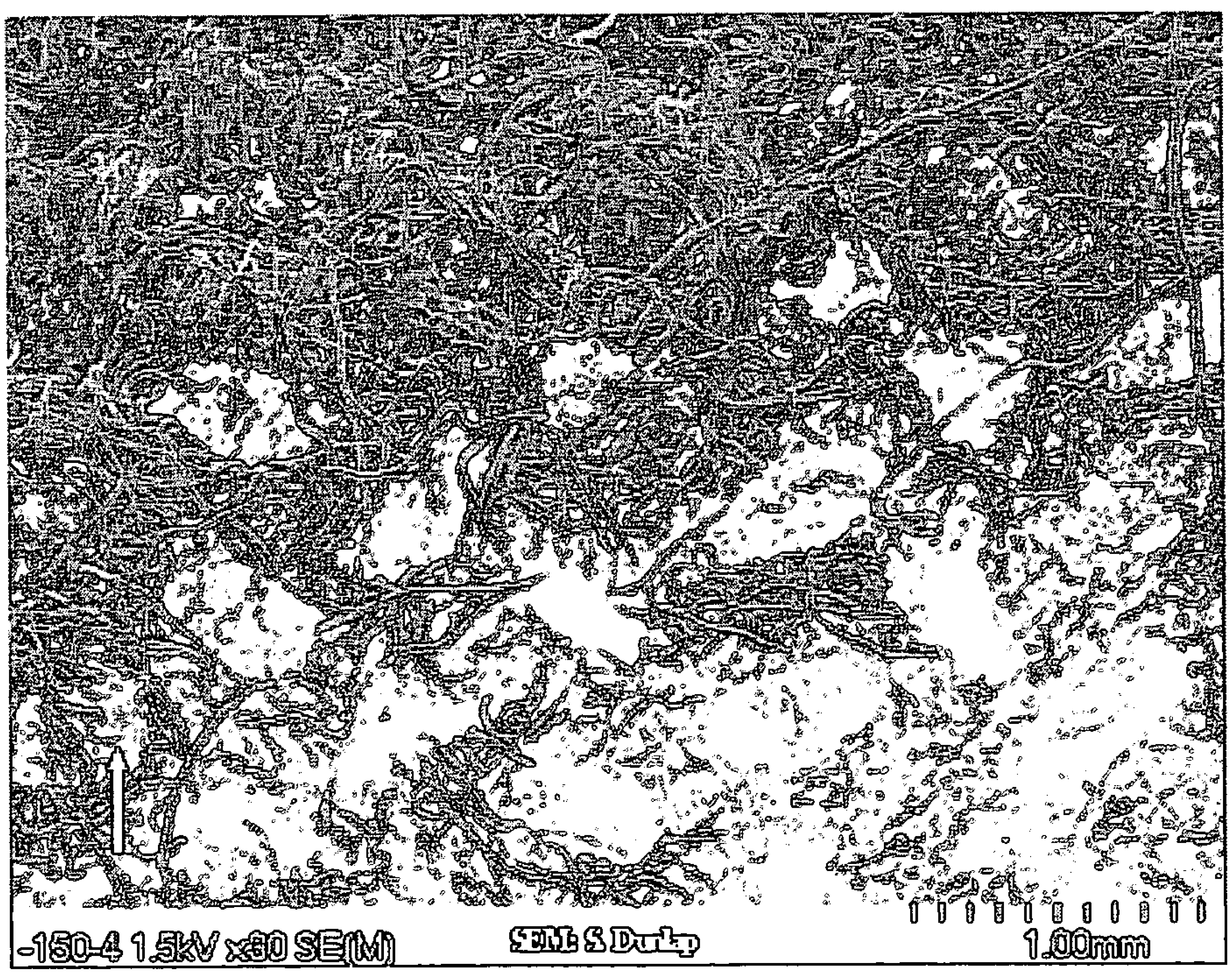


FIG. 2

ELASTOMERIC SPUN BONDED FABRIC OF POLYPROPYLENE AND PROCESS FOR MAKING

FIELD OF THE INVENTION

[0001] The present invention is directed to the field of so-called stretch non-woven fabrics, and specifically to spun bonded fabrics of polypropylene characterized by a high degree of crimping and high elastic recovery. The invention is also directed to a process for preparing the fabric.

BACKGROUND OF THE INVENTION

[0002] It is known in the art to subject oriented isotactic polypropylene (PP) fibers to elevated temperatures in order to achieve what is variously known as a "hard elastic,""high stretch-high recovery" or "springy" fiber. As discussed in Polypropylene Fibers: Science and Technology, M. Ahmed, pp. 412 ff, Elsevier Scientific Publishing Company (1982), these fibers have distinctive properties. In one aspect they are characterized by stacked crystalline lamellae wherein the lamellae surfaces are normal to the fiber axis —said to be "row-nucleated morphology." The "hard elastic fibers" therein described are characterized by recovery of ca. 80% from a 25% extension. They are also characterized by initial tensile modulus on the order of 2,800 MPa. This initial tensile modulus is orders of magnitude higher than that of known elastic fibers in wide commercial use in textiles such as Lycra ®.

[0003] The preparation of "hard elastic" polypropylene is described in detail in Herrman (U.S. Pat. No. 3,256,258). Disclosed therein are fibers having gamma orientation of 10-30° (as determined by X-ray diffraction) which fibers are produced in a melt spinning operation, subjected to spin-stretching, preferably without a post-draw step to produce a fiber having orientation of 10-50°. This step is followed in turn by heating to a temperature of 105 to 160° C., preferably 130-140° C., for a duration of 0.6 seconds to 24 hours, resulting in exposing individual fibers or fiber bundles to elevated temperatures.

[0004] The "hard elastic" fibers of Hermann are highly elastic, with low set and high and rapid elastic recovery. However, they are characterized by quite high elastic or Young's modulus. This means that considerable force needs to be applied to effect any degree of stretching. The hard elastic fibers of Hermann have had limited use in textiles because the fabric basis weight required for good coverage will not appear to the user to be elastic because of its high modulus, while low basis weight fabrics (which would appear to the user to be more elastic) provide insufficient cover and insufficient strength.

[0005] Preparation of spun bonded PP fabrics is a known art, and is described in detail in Ahmed, op.cit., pp. 443ff.

[0006] Hassenboehler et al., U.S. Pat. No. 5,244,482, discloses inelastic nonwovens of PP fibers heated to below their melting point and stretched in the machine direction to create nonwovens with a high degree of cross-direction (CD) recoverable stretch. Heating and stretching are accomplished by passing the nonwoven into an oven and withdrawing it at a higher velocity. Velocity ratios range from 1.1:1 to 2:1. Resulting webs recover at least 70% from a 50% elongation in the cross direction.

[0007] Mormon, U.S. Pat. No. 4,965,122, discloses a "reversibly necked" elastic material attained by, among other materials, a multilayer structure comprising a spun bonded PP fabric, the disclosed structure being subject to stretching, heating, and cooling in order to make the desired stretch product of the invention.

[0008] Both Hermann, op.cit., and Bersted et al. (U.S. Pat. No. 5,945,215) mention making nonwovens from hard elastic PP fibers but provide no teaching therefore. There is no teaching in the art for subjecting spun bonded isotactic polypropylene fabrics to elevated temperatures without constraint nor is there any suggestion of a process to produce a composite fabric having desirable stretch characteristics.

SUMMARY OF THE INVENTION

[0009] The present invention provides for a non-woven fabric composite consisting essentially of a mutually interbonded mixture of crimped isotactic polypropylene fiber segments and uncrimped hard elastic isotactic polypropylene fiber segments.

[0010] The present invention further provides for a process comprising exposing a spun bonded isotactic polypropylene fabric to a temperature of 150° C. to 170° C. over a period of 10 seconds to 5 minutes followed by cooling, said fabric being disposed in a manner to permit free-shrinkage in at least one dimension to occur during exposure, so that its thickness at least doubles.

[0011] The present invention further provides for textile goods fabricated from a fabric composite consisting essentially of a mutually interbonded mixture of crimped isotactic polypropylene fiber segments and uncrimped hard elastic isotactic polypropylene fiber segments.

BRIEF DESCRIPTION OF THE FIGURES

[0012] **FIG. 1A** is a photomicrograph depicting the as received spun bonded polypropylene fabric employed in the Examples.

[0013] **FIG. 1B** is a photomicrograph depicting the non-woven fabric composite of the invention showing crimped and uncrimped fiber segments extending between point-bonds, said point-bonds occupying less than 50% of the fabric area.

DETAILED DESCRIPTION

[0014] While it is known that heat-treatment of polypropylene fibers can make them "hard elastic," the instant invention provides a way to take advantage of this effect to make a nonwoven with a "soft-stretch feel". By heating in a way that allows unconstrained shrinkage, some of the fibers shrink first and pull in the other fibers. The fibers that are pulled in buckle out of plane. The fibers that shrink first carry the load and since they are elastic and there are relatively few of them, the initial tensile properties of the fabric show a low modulus and elasticity. The fibers that buckle provide coverage and ultimate strength under high extension.

[0015] The present invention provides for a non-woven fabric composite consisting essentially of a mutually interbonded mixture of crimped polypropylene fiber segments and uncrimped hard elastic polypropylene fiber segments. The ends of the fiber segments are point-bonded to other fiber segments, the length of the fiber segments being defined by the distance between the point-bonded ends thereof, and the fiber segments being of a length determined by the areal density and size of the point-bonds. The area of the point-bonds is in the range of 10-60% of the total fabric area.

[0016] The non-woven composite fabric of the present invention is characterized by fibers that are arranged in an array of randomly oriented fibers in a sheet structure. These fibers form an integrated sheet by virtue of being bonded to one another at some, but not all, crossover points. This is referred to in the art of non-wovens as point bonding. The distance between adjacent point-bonds along the length of any given fiber thereof defines a fiber segment that is the fundamental unit of the structure hereof.

[0017] The present invention is directed to the use of isotactic polypropylene fibers. The practitioner hereof shall understand that the recitation herein of "polypropylene" shall mean in every instance isotactic polypropylene unless specifically stated to be otherwise. Contemplated to fall within the scope of the present invention are the numerous commercial isotactic polypropylene grades sold as homopolymers when they actually contain a small fraction of ethylene comonomer.

[0018] The term "mutually interbonded" as employed herein shall be understood to mean that at least a portion of the crimped fiber segments are point-bonded to at least a portion of the uncrimped fiber segments so as to form a unitary structure made up of fibers having two different morphologies, namely crimped and uncrimped.

[0019] The average length of a fiber segment in the non-woven composite fabric hereof will be determined by the average area of the individual point-bonds, and by the density thereof. The point-bonds are characterized by the average area of individual point-bonds, and by the percentage of the total area of the fabric occupied by point-bonds. Thus, it is possible to have a given percentage of the total area of the fabric made up of relatively many point-bonds of small area or relatively few point-bonds of larger area.

[0020] The fibers in the non-woven composite of the present invention are typically, though not necessarily, of circular or near-circular cross-section, of a diameter of 1 to 100 micrometers, preferably from 10 to 30 micrometers. While there is no particular limitation on the size of point-bonds, the largest dimension of the point-bonds in typical practice hereof is in the range of 100 to 5000 micrometers, with 300 to 1500 micrometers preferred. According to the present invention, the total area of point-bonded areas shall be in the range of 10-60% of the total fabric area, preferably 20% to 40%. If the point-bonded areas exceed about 60% of the total area of the non-woven composite fabric, the fabric begins to exhibit qualities more characteristic of a plastic film than a textile. If the point-bonded areas represent less than about 5% of the total area of the fabric, the fabric exhibits insufficient strength for most practical applications.

[0021] While there is no particular limit to the areal weight of the non-woven composite fabric of the invention, for the practice of the invention for textile applications, fabric weight in the range of 0.3 oz/yd^2 to 3.0 oz/yd2 is satisfactory, with 0.6 to 1.5 oz/yd^2 preferred. As a general guideline to the practitioner hereof, the composite fabric of the invention is 2-2.5 times the basis weight of the original starting fabric.

[0022] The non-woven composite fabric of the invention consists essentially of a mutually interbonded mixture of crimped polypropylene fiber segments and uncrimped polypropylene fiber segments. The uncrimped polypropylene fiber segments are characterized as being in the hard elastic form. The non-woven composite fabric of the invention achieves its desirable combination of properties by virtue of the mixed fiber morphology thereof. The desired degree of cover for textile applications is achieved by virtue of the large portion of crimped fibers therein. The elastic properties are achieved because an applied load is borne only by the uncrimped fiber segments to extensions at which a significant number of the crimped fibers are no longer exhibiting crimp. Thus, the relatively low percentage of uncrimped fibers, which of themselves would amount to a low basis weight fabric, provides excellent stretch recovery at extensions up to about 30%, preferably 25%, (for unidirectionally shrunk fabrics, up to 40%) with a relatively low apparent Young's modulus, thereby affording the stretch and recovery properties normally associated with such well-known elastic textiles as spandex.

[0023] **FIG. 1A** is a photomicrograph of the as-received spun bonded polypropylene fabric employed as the starting material in the examples herein. The as-received fabric consisted of essentially continuous filament polypropylene fibers having a small amount of curvature but no crimp. **FIG. 1B** depicts the spun bonded fabric of the invention shown at the same magnification as that in **FIG. 1A**. There are numerous clearly crimped fibers, intermixed with still straight or slightly curved fibers that are in the hard elastic state.

[0024] In the typical practice of the present invention, about 2% to about 25%, preferably 5% to 15% of the fibers are in the uncrimped hard elastic form, as determined according to the method herein described. For purposes of comparison two identical fabric samples are subjected to the same heat history. One sample is permitted to shrink without constraint, thereby forming the non-woven composite fabric of the invention. The other sample is subjected to constraint during shrinkage such that the resulting fabric does not exhibit the composite nature of the non-woven composite fabric of the invention, but rather yields fabric in which all the fibers have undergone shrinkage. After shrinkage, the tensile modulus at a fixed level of extension is determined. Preferably this is performed at about 5% extension to minimize the role of any fiber that exhibits any significant degree of curvature. The ratio of the modulus of the specimen (which represents the non-woven composite fabric of the invention) to that of the fully shrunk fabric represents, for the purposes herein, the percentage of fibers that bear the load in that particular embodiment of the non-woven composite fabric of the invention.

[0025] Point bonding in the non-woven composite fabric of the invention may be by any convenient means such as is known in the art including adhesives and thermal bonding. Suitable for the practice of the invention are point-bonds ranging in area from ca. 0.1 mm^2 to ca. 3 mm^2. Point-bonds that are too large give the resulting fabric an inhomogeneous appearance and texture. Point-bonds that are too small provide insufficient integrity to the fabric. It is found in the practice of the invention that point-bonds of about 0.4 mm^2 are satisfactory. The total area occupied by the point-bonds in the non-woven composite fabric of the invention should not exceed 60% of the total area thereof.

[0026] In the process of the invention is prepared a non-woven fabric composite consisting essentially of a mixture of crimped polypropylene fiber segments and uncrimped polypropylene fiber segments the fiber segments having ends, the ends being point-bonded to other fiber segments, the length of the fiber segments being defined by the distance between the point-bonded ends thereof, and the segments being of a length determined by the areal density and size of the point-bonds, the area of point-bonds being in the range of 10-60% of the total fabric area. The achievable areal shrinkage depends in part on the area of point-bonds of the starting fabric. Because the point-bonds do not shrink much during the process, a starting fabric having a lower percentage of point-bonded area can shrink to a greater degree.

[0027] The process of the invention comprises exposing a spun bonded polypropylene fabric to a temperature of 150° C. to 170° C. over a period of 10 seconds to 5 minutes followed by cooling, the fabric being disposed in a manner to permit free-shrinkage in at least one dimension and to occur during at least a portion of the heating, the fabric characterized by point-bonds comprising 10-60% of the total fabric area. The crimping that occurs due to unconstrained shrinkage produces an increase in thickness that at least doubles the thickness. If the thickness does not at least double, the fabric has not been heated enough or has been constrained too much.

[0028] According to the process of the invention, a spun bonded fabric of isotactic polypropylene is subject to heating in an unconstrained configuration by exposure to a temperature of about 150° C. to about 170° C. for a period of 10 seconds to five minutes, so that 1% to 25%, preferably 5% to 15%, of the fiber segments therein will undergo shrinkage to form hard elastic PP fibers, and thus become the load-bearing fibers at low elongations, while the remaining fiber segments undergo crimping, thereby forming the non-woven composite fabric of the invention.

[0029] Spun bonded fabrics are known in the art, and are described in Ahmed, op.cit. pp. 443ff. In accord with Ahmed, op.cit., for the purposes of the present invention the term "spun bonded polypropylene" shall be taken to refer to a fabric formed from one or more continuous filaments prepared by extrusion spinning of isotactic polypropylene laid down in a random or quasi-random path or pattern with numerous overlaps forming cross-over points but substantially free of entanglements, and wherein at least a portion of the cross-over points the filaments converging thereat are bonded together by so-called point-bonds. Suitable for the practice of the invention are point-bonds ranging in area from about 0.1 mm^2 to about 3 mm^2. It is found in the practice of the invention that point-bonds of about 0.4 mm^2 are satisfactory. The total area occupied by the point-bonds in the spun bonded polypropylene fabric suitable for the process of the invention should not exceed 60% of the total area of the fabric.

[0030] While the invention is not in principle limited to spun bonded polypropylene fabrics in any given basis weight range, fabrics in the range of 8 to 80 g/m^2 are preferred. A spun bonded fabric is fabricated by laying down one or more continuous filaments in a random or quasi-random pattern with numerous overlaps forming crossover points. The effect of point-bonding is to subdivide the one or more continuous filaments into segments, herein referred to as "fiber segments" each fiber segment being characterized as having two ends and a segment length defined by the distance between the two ends, the two ends being defined as adjacent points along the continuous fiber, or filament, which are point-bonded. Thus, a fiber segment is a length of fiber between two point-bonds.

[0031] The spun bonded fabric suitable for the present invention is exposed to a temperature in the range of 150° C. to 170° C. for a period of time ranging from 10 seconds to 5 minutes while disposed in such manner that shrinkage may occur freely over the entire heating time, in at least one dimension. This causes the fabric to at least double in thickness.

[0032] The specific oven temperature at which the desired effect on a given fabric will be achieved will depend both upon the specific make-up of the fabric (fabric basis weight, thickness, fiber denier, etc.) and the specific design of the oven. Each oven and heating method has a heat transfer coefficient associated with it. Since the desirable results of the invention may depend upon transient effects, the actual temperature needed to achieve the desired heating rate will differ from oven to oven. It is expected that, with a modest amount of experimentation, the desired operating region can be determined for a specific heating apparatus and fabric.

[0033] The temperature range herein disclosed corresponds to the temperature of the oven in to which the fabric is inserted for shrinking. The longer the fabric is exposed to a given temperature, the more uniform the heating thereof will be. It is believed, although the invention hereof is not limited thereby, that the desirable benefits of the present invention are achieved in part by virtue of non-uniform heating of the fabric. As the fabric equilibrates thermally, at a temperature below the melting point of the fibers, the fabric will tend towards increasing percentages of fully shrunk, uncrimped fibers. As the fabric equilibrates at a temperature above the melting point, it will melt, thereby precluding realization of the benefits of the present invention.

[0034] According to the present invention, any given fiber segment in the spun bonded fabric suitable for the process of the invention may, when subjected to heating in accord with the process of the invention, undergo true shrinkage to the hard elastic form, thereby forming a straight or curvilinear fiber segment. The effect of the shrinkage is to cause the point-bonds to be closer together. Further according to the invention, any given fiber segment in the spun bonded fabric suitable for the process of the invention may, when subjected to heating in accord with the process of the invention, undergo no or little true shrinkage, forming a crimped fiber segment by virtue of the decrease in average distance between point-bonds caused by the shrinkage of those fibers which form the hard elastic fiber segments. According to the present invention, about 2% to about 25%, preferably 5% to 15% of the fiber segments form the straight, hard elastic fibers in the non-woven composite fabric of the invention.

[0035] The resulting product is a fabric with textile-like aesthetics wherein the crimped fibers provide bulk and cover while the hard elastic fibers provide stretchability and high stretch recovery. When the non-woven composite fabric of the invention is subject to strains smaller than that required to "stretch out" the crimps in the crimped fiber segments, an applied tensile or bending load is carried only by the shrunk, hard elastic fiber segments. Because only 1% to 25%, preferably 5% to 15%, of the fiber segments in the non-woven composite fabric of the invention are straight and in the hard elastic state the effective modulus of the non-woven composite fabric of the invention is much lower than it would be were the load being carried by all the fiber segments. As a result, the non-woven composite fabric of the invention may be made to exhibit the stretch and recovery properties of a variety of commercially available "stretch fabrics" such as spandex or rubberized textile goods. This may be achieved simply by adjusting the heating time and temperature as needed to achieve the desired result.

[0036] In one embodiment of the process of the invention, the spun bonded fabric suitable for the process of the invention is disposed in such manner that at the conclusion of the shrinkage accompanying the heating step, the thus treated fabric (now the non-woven composite fabric of the invention) remains in a tension free-state.

[0037] In one embodiment of the invention, the spun bonded fabric suitable for the process of the invention is disposed such that it is under tension in one planar dimension but unconstrained in the orthogonal planar dimension prior to heating. In such embodiment, low modulus elasticity results only in the unconstrained dimension. Both dimensions will be elastic, but one will be of much higher modulus.

[0038] The spun bonded fabric suitable for the process of the invention need not be held in any particular manner prior to heating so long as fabric remains unconstrained during the entire heating period. It has been found advantageous in the conduct of the specific experiments described hereinbelow to provide a frame for mounting each test specimen. A fabric sample larger than the frame in both planar dimensions is therein mounted by attaching with clips. An excess of fabric must be employed to ensure that the fabric remains tension-free throughout. The extent of excess fabric may be readily determined by ordinary experimentation on the particular fabric of interest.

[0039] Another method, more suitable for continuous production processes, is to overfeed in both the machine direction (MD) and transverse direction (TD) roll-stock of the spun bonded fabric suitable for the process of the invention into a tenter frame, and maintaining the speed and separation of the two rows of clips such that the desired degree of constraint—or lack thereof—is maintained.

[0040] In yet another method, the spun bonded fabric suitable for the process of the invention is fed to a simultaneous continuous biaxial stretching machine comprising individually driven clips so that the degree of overfeed in both the MD and TD can be continuously adjusted.

[0041] Heating may be accomplished by any convenient means known in the art. It has been found advantageous to employ an oven pre-heated to a predetermined temperature. In the process of the invention, the spun bonded fabric suitable for the process of the invention disposed in the manner desired concerning constraint, is introduced into a preheated air oven, and allowed to undergo heating for a period of 10 seconds to 5 minutes, preferably 30 seconds to two minutes.

[0042] The present invention further provides for textile goods fabricated from a fabric composite consisting essentially of a mixture of crimped polypropylene fiber segments and uncrimped hard elastic polypropylene fiber segments, the fiber segments having ends, the ends being point-bonded to other fiber segments, the length of the fiber segments being defined by the distance between the point-bonded ends thereof, and said segments being of a length determined by the areal density and size of the point-bonds, the area of point-bonds being in the range of 10-60% of the total fabric area

[0043] The textile goods incorporating the non-woven composite fabric of the invention include, but are not limited to, disposable apparel such as laboratory cover-alls including clean room suits, surgical gowns, surgical drapes, gloves, glove liners; components of disposable hygiene products such as diapers; and durable articles such as thermal underwear, shell fabrics for jackets and coats, blankets and bedding, upholstery fabrics, mattress ticking, and filtration components.

[0044] This non-woven composite fabric can also be used as a component in construction of other nonwovens and laminates. For example, staple fibers or wood pulp could be hydroentangled into it, or it could be laminated to an extensible fabric to modify the surface, while retaining its stretch and recovery properties.

[0045] The textile goods of the invention may be prepared by ordinary means as are commonly practiced in the art. Goods may be cut and sewn or seams may be formed by melt sealing. One of skill in the art will recognize that use of the non-woven composite fabric of the invention in a wide variety of textile goods will involve a straightforward application of known methods of fabrication, particularly those which have been developed for handling fabrics containing spandex fibers.

[0046] Applicants specifically incorporate the entire content of all cited references in this disclosure. Where a range of numerical values is recited herein, unless otherwise stated, the range is intended to include the endpoints thereof, and all integers and fractions within the range. It is not intended that the scope of the invention be limited to the specific values recited when defining a range.

[0047] The invention is further described in the specific embodiments hereinbelow.

EXAMPLES

Comparative Example 1

[0048] A web of commercial spun bond polypropylene (SBPP) of 0.5 ounces per square yard (16.5 g/m2) basis weight and a thickness of 0.006 in (152 μm) was cut to a size of 11⅝ in (29.53 cm) by 9⅜ in (23.81 cm) and clipped to a metal frame with inside dimensions of about 8.5 in (21.59 cm) by 7 in (17.78 cm). The framed SBPP was then hung in a preheated convection oven, and removed after a time of 60 sec. During the 60 sec heating time, the maximum temperature measured on a thermocouple placed in the air near the SBPP was 168° C. The test specimen was observed to be tightly held in the frame.

[0049] The thus-treated specimen was removed from the frame and was found to be 8.5 in (21.59 cm) by 7 in

(17.78cm) in size. The planar shrinkage of the heat-treated SBPP was therefore about 25% in each dimension. The average thickness of the heat-treated specimen was 0.0099 in (250 μm). Strips 1 in wide by 7 in long were cut from the heat-treated specimen and the average tensile modulus of the heat-treated SBPP was measured to be 23.0 kpsi. Strips were strained to 20% three times and then once to 15% and showed an average set of 3.84%.

Example 1

[0050] The materials and procedures of Comparative Example 1 were employed except that the oven was pre-heated to a lower temperature. The maximum temperature recorded in proximity to the fabric was 161.3° C. When removed from the oven, the specimen was found to be 8.5 in (21.59 cm) by 7 in (17.78cm) in size with an average thickness of 0.0155 in (394 μm). The planar shrinkage was about 25%. The average modulus was measured to be 1.88 kpsi, and the set was measured as in Comparative Example 1 to be 4.45%. This web came off barely tight on the frame. It had just reached its natural shrink level with these conditions.

Example 2

[0051] The materials and procedures of Example 1 were employed except that the SBPP starting specimen was cut to a dimension of 12.5 in (31.75 cm) by 10 in (25.4 cm). The maximum temperature recorded during the 60 sec heating period was 161.7° C. When removed from the oven, the heat-treated specimen was found to be 9.5 in (24.13 cm) by 8 in (20.32 cm) with an average thickness of 0.0167 in (424 μm). The shrinkage in both directions was about 22% and since the heat-treated specimen dimensions were greater than the frame dimensions, the heat-treated specimen was not tight on the frame after heating. The average modulus of the heat-treated SBPP is 0.71 kpsi, and the set was measured to be 5.1%.

Comparative Example 2

[0052] The materials and procedures of Example 1 were employed except that the starting specimen of SBPP was cut to a dimension of 8¾ in (22.2 cm) by 7 in (17.78 cm) and the oven was preheated to a slightly lower temperature. The maximum temperature recorded during the 60 sec heating period was 160.7° C. When removed from the oven, the fabric specimen was found to be 8¾ in (22.2 cm) by 7 in (17.78 cm) with an average thickness of 0.0073 in (185 μm). The average modulus was measured to be 15.98 kpsi, and the set was measured to be 3.31 %.

Comparative Example 3

[0053] The materials and procedures of Comparative Example 2 were followed except that the oven was pre-heated to a lower temperature. The maximum temperature recorded during the 60 sec heating period was 149.4° C. When removed from the oven, the SBPP measured 8¾ in (22.2 cm) by 7 in (17.78 cm) with an average thickness of 0.0072 in (183 μm). The average modulus was measured to be 7.85 kpsi, and the set was measured to be 2.97%.

[0054] In this case, the temperature was not high enough to create the desired type of shrinkage, so the desired bulky web with soft-stretch was not created.

Examples 3 and 4

Comparative Examples 4 and 5

[0055] In these examples and comparative examples, a Roaches Tenter Frame Oven was employed. This oven is intended to model a commercial tenter frame oven. In a commercial tenter frame, a continuous fabric enters one end and leaves the other. In the Roaches tenter frame a small fabric specimen was mounted on a pin frame which was slid into a heating chamber for a pre-set exposure period, then slid out automatically after that period. In the case of the commercial unit, the residence time depends on velocity and oven length. The level of constraint (minimization of constraint) can be accomplished in a commercial oven by gathering the fabric in the machine direction and by allowing it to sag in the cross direction.

[0056] The spun bonded fabric of Examples 3 and 4 and Comparative Examples 4 and 5 were cut into over-sized specimens and mounted into the specimen pin frame of the oven. The exposure time was preset. At the push of a button on the oven, the frame slid into a heated chamber for the pre-selected hold-time and was then automatically slid out. The fabric was placed on the pin frame with gathers in both the x and y directions to allow shrinkage without constraint.

[0057] Air circulation in the Roaches oven was more uniform and thorough than in the standard laboratory convection oven employed in Examples 1 and 2 and Comparative Examples 1-3. It was found, however, that the oven temperature varied by location within the oven. In order to achieve high precision, one region of the oven was carefully calibrated for temperature, and the specimens used for evaluation were cut from same portion of the larger test specimen after exposure in the calibrated region of the oven.

[0058] Area shrinkage was determined from the following formula:

{area shrinkage=[(initial area)−(final area)]/(initial area)}area=length×width

[0059] The term "constrained" means that, at the conclusion of the test, the fabric specimen was held tightly in the frame. "Unconstrained" means that at the conclusion of the test, the fabric specimen was not held tightly in the frame, but was of larger dimension that the frame.

[0060] The term "soft-stretch" refers to a subjective evaluation of the fabric that is associated with the percentage of fibers carrying the applied load, as described hereinabove. The term "soft-stretch" means that only ca. 1% to 25% of the fibers are carrying the load because the fabric is easy to stretch by hand, comparable to spandex, and recovers with permanent set of less than 10%.

Comparative Example 4

[0061] A specimen was overfed to the pin-frame and exposed to a temperature of 150° C. for 60 seconds. The resulting specimen was unconstrained, showed areal shrinkage of 9%, and did not have the desired "soft-stretch" character, or the desired morphology. Its thickness was measured to be 0.0078 inches, a factor of 1.3 times the original thickness of 0.0060 inches.

Example 3

[0062] A specimen was overfed to the pin-frame and exposed to a temperature of 160° C. for 20 seconds. The resulting specimen was unconstrained, showed areal shrinkage 45%, and showed good soft-stretch character. This specimen, while not tightly held on the frame, did appear to be just beginning to experience constraint at the end of the exposure time. Its thickness was measured to be 0.0157 inches, a factor of 2.6 times the original thickness of 0.0060 inches.

Comparative Example 5

[0063] A specimen was overfed to the pin-frame and exposed to a temperature of 165° C. for 10 seconds. The resulting specimen was fully constrained by the frame, showed areal shrinkage of 50%, and did not exhibit either the desirable bulky morphology or the soft-stretch character. Its thickness was measured to be 0.0097 inches, a factor of 1.6 times the original thickness of 0.0060 inches.

Example 4

[0064] A specimen was overfed to the pin-frame and exposed to a temperature of 160° C. for 20 seconds. This specimen was overfed to a greater degree than that in Example 3 so that the resulting specimen showed no sign of any incipient constraint. A real shrinkage was 59% and the morphology and soft-stretch character were excellent. Its thickness was measured to be 0.0224 inches, a factor of 3.7 times the original thickness of 0.0060 inches.

Example 5

[0065] The spun bonded fabric of Comparative Example 1 was over-fed to the pin-frame of the Roaches Tenter Frame in a series of experiments which were aimed at determining the oven temperature range that corresponded to the preferred areal shrinkage range of 45% -65% at different exposure durations. Results are shown in Table 1.

TABLE 1

Temperature range for 45–65% shrinkage

Exposure Time (seconds)	Temperature Range (° C.)
10	160–163
30	159.5–162.5
300	159–161

Comparative Example 6

[0066] A single fiber was extracted from the spun bonded polypropylene fabric of Comparative Example 1, and was fixed in place by gluing one end to a microscope slide. It was sequentially stretched to elongations of ca. 5,10, 20, 25, 40, 50, 65, and 75% with a final stretch of 89%. The fiber was allowed to relax for about 5 seconds between stretches. The degree of set and recovery were determined at the final stretch according to the formula:

$$\%\ \text{set} = 100 \times \frac{(\text{recovered length after stretching}) - (\text{original length before stretching})}{(\text{original length before stretching})}$$

$$\%\ \text{recovery} = 100 \times \frac{(\text{stretched length}) - (\text{recovered length after stretching})}{(\text{stretched length}) - (\text{original length before stretching})}$$

Results are shown in Table 2.

Example 6

[0067] The procedure of Comparative Example 6 was repeated except that 1) the fiber was first placed without constraint on the hot stage of a microscope at 155° C. for a time sufficiently long to allow it to undergo complete shrinkage; 2) it was sequentially elongated only to ca. 25%, 45%, and a final elongation of 87%. Set and recovery were determined; results are shown in Table 2.

TABLE 2

Set and Recovery of Extracted Fiber

Sample	Elongation (%)	Set (%)	Recovery (%)
Fiber extracted from SBPP	89	43	51
Fiber extracted from SBPP with heat treatment	87	25	72

1. A non-woven fabric composite consisting essentially of a mutually interbonded mixture of crimped isotactic polypropylene fiber segments and uncrimped hard elastic isotactic polypropylene fiber segments.

2. The non-woven fabric composite of claim 1 further comprising point-bonds, the total area of point-bonds in the range of 10-60% of the total fabric area.

3. The non-woven fabric composite of claim 2 wherein the point-bonds range in size from about 0.1 mm^2 to about 3 mm^2.

4. The non-woven fabric composite of claim 1 wherein the fiber segments are characterized by an approximately circular cross-section of a diameter of 1 to 100 micrometers.

5. The non-woven fabric composite of claim 1 further characterized by a fabric basis weight of 8 to 80 g/m^2.

6. The non-woven fabric composite of claim 1 wherein about 2 to about 25% of the fibers are in the uncrimped hard elastic form.

7. A process for producing a non-woven fabric composite comprising exposing a spun bonded isotactic polypropylene fabric to a temperature of 150° C. to 170° C. over a period of 10 seconds to 5 minutes followed by cooling, the fabric being disposed in a manner to permit free-shrinkage in at least one dimension, which causes the fabric to at least double in thickness.

8. The process of claim 7 wherein the spun bonded isotactic polypropylene fabric further comprises point-bonds comprising 10-60% of the total fabric area.

9. The process of claim 8 wherein the point-bonds range in size from about 0.1 mm^2 to about 3 mm^2.

10. The process of claim 7 wherein the spun bonded isotactic polypropylene fabric is characterized by fiber segments having an approximately circular cross-section of a diameter of 1 to 100 micrometers.

11. The process of claim 7 further characterized by a fabric basis weight of 8 to 80 g/m^2.

12. The process of claim 7 further comprising disposing the fabric in such manner that it is under tension in one planar dimension but unconstrained in the orthogonal planar dimension.

13. A textile product comprising a non-woven fabric composite consisting essentially of a mutually interbonded mixture of crimped isotactic polypropylene fiber segments and uncrimped hard elastic isotactic polypropylene fiber segments.

14. The textile product of claim 13 further comprising point-bonds, the total area of which is in the range of 10-60% of the total fabric area.

15. The textile product of claim 14 wherein the point-bonds range in size from about 0.1 mm^2 to about 3 mm^2.

16. The textile product of claim 13 wherein the fiber segments are characterized by an approximately circular cross-section of a diameter of 1 to 100 micrometers.

17. The textile product of claim 13 further characterized by a fabric basis weight of 8 to 80 g/m^2.

18. The textile product of claim 13 wherein about 2 to about 25% of the fibers are in the uncrimped hard elastic form.

19. The textile product of claim 13 in the form of a product selected from the group consisting of disposable apparel such as laboratory cover-alls including clean room suits, surgical gowns, surgical drapes, gloves, glove liners; components of disposable hygiene products such as diapers; and durable articles such as thermal underwear, shell fabrics for jackets and coats, blankets and bedding, upholstery fabrics, mattress ticking, and filtration components.

20. A non-woven fabric composite made by the process of claim 7.

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