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(54) PROCESS FOR PRODUCING A NONWOVEN POLYESTER STAPLE FIBER FABRIC

(75) Inventor: **Hironori Goda**, Matsuyama-shi (JP)

Correspondence Address:
SUGHRUE MION, PLLC
2100 PENNSYLVANIA AVENUE, N.W.
SUITE 800
WASHINGTON, DC 20037 (US)

(73) Assignee: **TEIJIN FIBERS LIMITED**

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(57) **ABSTRACT**

Polyester staple fibers containing a polymeric blend of 0.5 to 15 mass % of a polyolefinic polymer with a matrix polyester polymer, 50% or more of the surface area of each fiber being formed by the polymeric blend, are useful for forming a nonwoven fabric with soft hand and a uniform texture by using various web-forming methods, for example, an air laid, wet laid or carding method.

PROCESS FOR PRODUCING A NONWOVEN POLYESTER STAPLE FIBER FABRIC

CROSS REFERENCE TO RELATED APPLICATION

[0001] This is a Continuation application of U.S. application Ser. No. 10/487,222 filed on Feb. 20, 2004, which is a 371 of PCT Application No. PCT/JP03/07754 filed on Jun. 18, 2003, which applications are incorporated herein by reference in their entirety.

TECHNICAL FIELD

[0002] The present invention relates to a polyester staple fiber and a nonwoven fabric comprising the same.

TECHNICAL BACKGROUND

[0003] Polyester staple fibers have excellent mechanical properties and resistances to chemicals, and therefore are widely employed for nonwoven fabrics. However, the nonwoven fabrics comprising conventional polyester staple fibers are disadvantageous in that the fabrics exhibit an undesirable creaky touch and an unsatisfactory soft hand, in comparison with nonwoven fabrics comprising nylon or polyolefin staple fibers.

[0004] It is known that the nonwoven fabrics can be produced from staple fibers by a method in which a web is formed from the staple fibers by a carding method, a wet laid method or an air-laid method and then the staple fibers in the web are entangled with each other by a needle-punching or a spunlacing or hydro-entangling procedure, or are heat-bonded under pressure by a calender or embosser, or the web is impregnated with an emulsion of a binder and dried to chemically-bond the staple fibers in the web with each other. In the case where, in the above-mentioned methods, the web is formed by the air laid procedure, the polyester staple fibers are disadvantageous in that, in comparison with nylon or polyolefin staple fibers, the smoothness of the polyester stable fibers is low and, when crimped, the resultant crimped fibers easily exhibit a high percentage of crimp, and thus a low fiber-opening property in the ambient air atmosphere, and therefore, production of a nonwoven fabric having a uniform texture from the polyester staple fibers is difficult. This trend is significantly realized when undrawn polyester fibers or copolymeric polyester fibers which have a low degree of orientation and a low degree of crystallinity and are preferred as binder fibers, are employed for the production of the nonwoven fabrics. Therefore, there is a limit in the production of the nonwoven fabrics having a uniform texture, from a web formed by using the binder fibers, particularly from 100% of the binder fibers, by the air laid method. Also, even in the case where the carding method or wet laid method is employed, a production of nonwoven fabrics having a uniform texture from the polyester staple fibers having a low surface smoothness and thus exhibiting a poor fiber-opening property, is difficult.

[0005] The above-mentioned trend is further intensified when the web is formed from the binder fibers by a carding method.

[0006] The difficulty in the production of the nonwoven fabrics appears to be caused from a high rigidity of the polyester staple fibers and friction between individual polyester staple fibers. To solve this problem, Japanese Examined Patent Publication No. 48-1480 discloses a method in which a dimethylsiloxane compound or a amine-modified silicone compound is applied to surfaces of the polyester fibers and cross-linking the applied compound by heating. However, in the case where the treated polyester staple fibers are formed into a web by, for example, a carding method, the staple fibers of the Japanese publication have very little friction between the fibers and thus exhibit an insufficient fiber-entangling property and the resulting web is easily broken. In this case, when the web is formed by the wet laid method, as the staple fibers of the Japanese publication repel water, the fibers are not evenly dispersed in water. Also, while the web is formed by the air-laid method, static electricity is generated on the staple fibers of the Japanese publication and, in the resultant web, the staple fibers are unevenly distributed. Further, when the staple fibers of the Japanese publication are used as binder fibers, the surface-treating agent applied to the surfaces of the polyester staple fibers forms a barrier against the heat-bonding of the fibers.

SUMMARY OF THE INVENTION

[0007] The present invention was made to solve the problems of the prior arts. Namely, an object of the present invention is to provide polyester staple fibers enabling a nonwoven fabric having a soft hand and a uniform texture to be realized, and a nonwoven fabric comprising the polyester staple fibers. Further, the present invention is intended to provide a nonwoven fabric produced from a web formed from the polyester staple fibers by an air laid method and having the above-mentioned excellent quality.

[0008] The inventors of the present invention found that polyester staple fibers, portions of the peripheral surfaces of which are formed from a polymeric blend of a polyester and a polyolefin mixed and dispersed in the polyester, exhibit appropriate friction between the staple fibers, and a nonwoven fabric having not only a soft hand, but also a very uniform texture can be obtained in the case where the content of the polyolefin in the fibers is established within a specific range of the content.

[0009] Namely, the above-mentioned object can be attained by the polyester staple fiber of the present invention comprising a polymeric blend comprising 0.5 to 15% by mass of a polyolefinic polymer mixed and dispersed in a matrix polyester polymer, 50% or more of the surface area of the fiber being formed by the polymeric blend.

[0010] In the polyester staple fiber of the present invention, the polyolefinic polymer preferably comprises at least one member selected from polyethylene, polypropylene, ethylene-propylene copolymers and polyethylene copolymers and polypropylene copolymers in which at least one ethylenically unsaturated monomer different from ethylene and propylene is block-copolymerized or graft-copolymerized.

[0011] In the polyester staple fiber of the present invention, the matrix polyester polymer is preferably selected from polyalkylene terephthalates and polyalkylene terephthalate-isophthalate copolymers.

[0012] The polyester staple fiber of the present invention preferably has a degree of crystallization of 20% or less or a birefringence of 0.05 or less.

[0013] The polyester staple fiber of the present invention preferably has a concentric or eccentric core-in-sheath conjugate structure in which the sheath section is formed from the polymeric blend.

[0014] The polyester staple fiber of the present invention preferably has a fiber length of 2 to 30 mm, and a plane zigzag type or omega (ω) type crimps in the number of crimps of 3 to 13 crimps/25 mm and a percentage of crimp of 3 to 15%.

[0015] The polyester staple fiber of the present invention preferably has a fiber length of 30 to 200 mm, and a number of crimps of 5 to 30 crimps/25 mm and a percentage of crimps of 3 to 30%.

[0016] The nonwoven fabric (1) of the present invention comprises a plurality of the polyester staple fibers as mentioned above, and formed by an air laid web-forming method.

[0017] The nonwoven fabric (1) of the present invention preferably has a percentage of non-opened fibers of 5% or less.

[0018] The nonwoven fabric (2) of the present invention comprises a plurality of the polyester staple fibers as mentioned above, and is formed by a wet laid web-forming method.

[0019] The nonwoven fabric (3) of the present invention comprises a plurality of the polyester staple fibers as mentioned above and is formed by a carding web-forming method.

[0020] The nonwoven fabric (1), (2) or (3) of the present invention preferably has a bending resistance of 70 mm or less, determined by the cantilever method.

BEST MODE CARRYING OUT THE INVENTION

[0021] The staple fibers of the present invention are polyester staple fibers 50% the surface area of which are formed by a polymeric blend comprising a polyolefinic polymer mixed and dispersed in a matrix polyester polymer.

[0022] The polyester polymers usable for the present invention include, for example, polyesters of aromatic dicarboxylic acids with aliphatic diols, such as polyalkylene terephthalates, for example, polyethylene terephthalate, polytrimethylene terephthalate and polybutylene terephthalate and polyalkylene naphthalates, for example, polyethylene naphthalates; polyesters of cycloaliphalic dicarboxylic acids with aliphatic diols, for example, polyalkylene cyclohexane-dicarboxylates; polyesters of aromatic dicarboxylic acids with cycloaliphatic diols, for example, polycyclohexanedimethanol terephthalate; polyesters of aliphatic dicarboxylic acids with aliphatic diols, for example, polyethylene succinate, polybutylene succinate, polyethylene adipate and polybutylene adipate; and polyhydroxycarboxylate esters, for example, polylactate esters and polyhydroxybenzoate esters. The polyesters usable for the present invention may be copolyesters containing at least one copolymerizing component selected from acid components, for example, isophthalic acid, phthalic acid, adipic acid, sebacic acid, α,β-(4-carboxyphenoxy)ethane, 4,4-dicarboxyphenyl, 5-sodium sulfoisophthatic acid, 2,6-naphthalene dicarboxylic acid and 1,4-cyclohexanedicarboxylic acid and esters of the above-mentioned acids, and diol components, for example, diethylene glycol, 1,3-propanediol, 1,4-butanediol, 1,6-hexanediol, neopentyl glycol, 1,4-cyclohexane dimethanol and polyalkylene glycol. The copolymerizing component may be selected from compounds having three or more carboxylic acid groups or hydroxyl groups, for example, pentaerythritol, trimethylolpropane, trimellitic acid, and trimesic acid, to cause the resultant copolyesters have branched chains. In the present invention, the above-mentioned polyester polymers (copolymers) may be employed alone or in a mixture of two or more thereof.

[0023] The polyester polymer and the polyolefinic polymer may contain one or more of additives, fluorescent brightening agents, stabilizers, flame retardants, flame retardant assistants, ultraviolet ray absorbers, anti-oxidants and various coloring pigments, as long as the effects of the present invention are not degraded.

[0024] In the polymeric blend for the polyester staple fibers of the present invention, the content of the polyolefinic polymer to be mixed and dispersed in the matrix polyester polymer must be in the range of from 0.5 to 15% by mass, preferably from 1 to 10% by mass, more preferably 2 to 7% by mass, still more preferably 2 to 5% by mass, based on the mass of the polymeric blend. If the content of the polyolefinic polymer is less than 0.5% by mass, the object of the present invention, namely a preparation of the polyester staple fiber-containing nonwoven fabric having the soft hand and the uniform texture cannot be attained. Also, if the polyolefinic polymer content is more than 15% by mass, not only the above-mentioned effect is saturated or cannot be obtained, but also the fiber-forming property of the resultant polymeric blend is degraded and thus the target staple fibers of the present invention cannot be produced.

[0025] In the polyester staple fibers of the present invention, 50% or more, preferably 70% or more, more preferably 90% to 100%, of the surface areas of the fibers must be formed from the polymeric blend. If the proportion of the surface area formed by the polymeric blend is less than 50%, the resultant nonwoven fabric exhibits an insufficient softness and an unsatisfactory uniformity in texture. The staple fibers satisfying the above-mentioned requirement include staple fibers formed from 100% by mass of the polymeric blend and conjugate staple fibers in which the polymeric blend forms 50% or more of the surface areas of the fibers. The conjugate staple fibers include concentric core-in-sheath type, eccentric core-in-sheath type, side-by-side type and islands-in-sea type and segment pie type conjugate staple fibers. Preferably, the concentric and eccentric core-in-sheath conjugate staple fibers in which 70% or more, more preferably 100% of the fiber surface area is formed by the polymeric blend sheath section, are employed for the present invention.

[0026] The polyester staple fibers of the present invention may be hollow fibers or non-hollow fibers. The cross-sectional profile of the polyester staple fibers of the present invention is not limited to circular and may be selected from irregular profiles, for example, oval, multi-lobed, for example, three to eight lobed and polygonal such as, as examples, triangle to octagonal profiles.

[0027] The effect of the present invention is significantly realized in the polyester staple fibers having a birefringence of 0.05 or less or a degree of crystallinity of 20% or less.

[0028] In the conventional polyester staple fibers having a birefringence of 0.05 or less or a degree of crystallinity of 20% or less, there is a trend to increase the friction between the fibers, and thus the resultant nonwoven fabric may exhibit a degraded hand, reduced fiber-opening property and, thus, an unsatisfactory uniformity in texture of the fibers. This trend appears to be significant in the low orientation fibers (undrawn fibers) produced by melt-spinning a polyalkylene terephthalate, particularly, a isophthalic acid-copolymerized polyalkylene terephtalate, at a low taking-up speed of 2000 m/minute or less. Among the undrawn polyalkylene terephthalate fibers, the above-mentioned trend appears to be very significant in the fibers formed from the polyethylene terephthalate having a low degree of crystallinity and the copolymerized polyethylene terephthalate with 5 to 50 molar % of isophthalic acid based on the total molar amount of the acid component. The above-mentioned polyester staple fibers can be heat-bonded under pressure to each other and are usable as binder fibers for the nonwoven fabric. When the above-mentioned polyester polymer is used as a matrix polymer of the polyester staple fibers of the present invention, the resultant polyester staple fibers can be used as binder fibers without causing the above-mentioned problem. Also, the resultant polyester staple fibers of the present invention are useful for the production of the nonwoven fabric having a desired soft hand and uniform texture.

[0029] There is no limitation to the thickness of the individual polyester staple fibers of the present invention. Usually, the thickness of the polyester staple fibers of the present invention is preferably in the range of 0.01 to 500 dtex.

[0030] The polyester staple fibers of the present invention can be produced by, for example, the process illustrated below. A melt of a polymeric blend of a polyester polymer with a polyolefinic polymer is extruded through a (melt-)spinneret having a plurality of spinning orifice of a conventional (melt-)spinning apparatus, the extruded filamentary streams of the melt are cooled and solidified by blowing cooling air toward the melt streams and drafting, the solidified filaments are taken-up at a speed of 100 to 2000 m/minute to provide undrawn polyester multi-filament yarn.

[0031] The melt of the polymeric blend is prepared by blending a melt of the polyester polymer with a melt of the polyolefinic polymer by a static mixer, or dynamic mixer or by blending pellets of the polyester polymer and the polyolefinic polymer with each other in a desired mass ratio and (melt-)kneading the blend by using a (melt-)extruder, and the resultant blend melt is fed to the (melt-)spinneret.

[0032] In the production of the undrawn polyester conjugate filaments, the same procedures as mentioned above are carried out, except that a melt of the polymeric blend and a melt of a polyester resin are separately fed into a (melt-)spinneret in which the melts of the polymeric blend and the polyester resin are combined so as to form conjugate filaments of each of which, 50% or more of the surface area are formed by the polymeric blend.

[0033] The resultant undrawn filaments are drawn at a desired draw ratio in hot water at a temperature of 70 to 100° C. or in steam at a temperature of 100 to 125° C., and optionally the resultant drawn filaments are crimped, oiled with a finish oil in consideration of the use and the object of the resultant staple fibers, dried and relaxed. The resultant filaments are cut into staple fibers having a desired fiber length, to obtain the target polyester staple fibers. In the procedures, the oiling agent may contain a silicone compound of the type and in the amount which do not hinder the attainment of the object of the present invention. Also, the polyester staple fibers of the present invention having a birefringence of 0.05 or less or a degree of crystallinity of 20% or less can be obtained by the same procedures as mentioned above, except that the drawing procedure is omitted and the finish oil is applied to the undrawn filaments and the oiled undrawn filaments are dried at the temperature for the time which do not cause the degree of crystallinity of the dried filaments to exceed 20%. In the production of the nonwoven fabric from the polyester staple fibers of the present invention, preferably, the staple fiber length is adjusted and the crimps are imparted in response to the method of forming a web from the fibers, as follows.

[0034] For example, in the case where the web is formed by an air laid method, the staple fiber length is preferably adjusted to 2 to 30 mm, more preferably 3 to 20 mm. By adjusting the fiber length to not less than 2 mm the desired staple fibers can be industrially produced at a satisfactory process stability, and by controlling the fiber length to not more than 30 mm, the resultant staple fibers exhibit an enhanced fiber-opening property, and a high resistance to the generation of fiber lumps. The polyester staple fibers may be crimped fibers or may not crimped fibers, in view of the use of the resultant nonwoven fabric. Namely, where the target nonwoven fabric must have a high bulkiness, the staple fibers are preferably crimped fibers, and where the target nonwoven fabric must have an enhanced fiber-opening property upon jetting air and an improved property of being uniformly scattered by air jet, no crimps may be imparted to the staple fibers. Where the crimped staple fibers are used in the web-forming air laid method, preferably the number of crimps is 3 to 13 crimps/25 mm and the percentage of crimps is 3 to 15%. When the number of crimp is adjusted to not more than 13 crimps/25 mm, and the percentage of crimps is regulated to not more than 15%, the resultant nonwoven fabric may exhibit a satisfactory fiber-opening property by air-blowing. As the polyester staple fibers of the present invention easily have a low number of crimps and percentage of crimps in comparison with those of the conventional polyester staple fibers, the adjustment of the number and percentage of crimps within the above-mentioned range is easy. Also, to impart an appropriate bulkiness to the polyester staple fibers of the present invention, preferably, the number and percentage of crimps are adjusted to not less than 3 crimps/25 mm and not less than 3% respectively. The mode of crimping is preferably in a plane zigzag or ω (omega) form which are formed within a plane, rather than a three dimensional spiral crimping mode, because the plane zigzag or ω crimped staple fibers exhibit a higher fiber-opening property than the spirally crimped staple fiber.

[0035] By adjusting the number and percentage of crimps as mentioned above, the content of non-opened staple fibers in the resultant web by the air laid method can be reduced to 5% by mass or less.

[0036] In the case where the web for the nonwoven fabric is produced by a wet laid web-forming method, due the above-mentioned reasons, the fiber length of the polyester staple fibers is preferably 2 to 30 mm, more preferably 3 to 20 mm. The staple fibers may be crimped or not crimped.

Namely, the crimps are imparted in consideration of the use and purpose of the target nonwoven fabric, to the staple fibers. However, in view of the uniformity in distribution of the staple fibers dispersed in an aqueous slurry of the staple fibers for the wet laid web-forming procedure, no crimped staple fibers are preferred for the wet laid web-forming method.

[0037] In the case where the web for the target nonwoven fabric is formed by a carding web-forming method, the length of the polyester staple fibers is preferably adjusted to 30 to 200 mm, more preferably 35 to 150 mm, still more preferably 40 to 100 mm. The fiber length not exceeding 30 mm may enable the breakages of the resultant web due to insufficient entanglement of the staple fibers with each other to be prevented or reduced. Also, a fiber length not exceeding 200 mm may enable the opening property of the resultant staple fibers on the carding machine to be enhanced and the uniformity in texture of the resultant web to be improved.

[0038] To improve the passing property of the staple fibers through the carding machine, the crimped polyester staple fibers are preferably employed. The preferable number and percentage of crimps to be imparted to the polyester staple fibers are 5 to 30 crimps/25 mm and 3 to 30%, respectively. The number and percentage of crimps adjusted not more than 30 crimps/25 mm and not more than 30% may enable the resultant polyester staple fibers exhibit a good opening property on the carding machine and the resultant web to exhibit a satisfactory uniformity in texture. Also, the number and percentage of crimps adjusted to not less than 5 crimps/25 mm and not less than 3% may enable the breakages of the resultant web due to the insufficient entanglement of the staple fibers with each other to be prevented or reduced. The mode of crimping may be conventional plane zigzag or a ω (omega) mode or three dimensional spiral node.

[0039] The nonwoven fabric comprising the polyester staple fibers of the present invention has a soft touch and good hand and can exhibit a resistance to bending, which represents a softness of the fabric, of 70 mm or less, determined by the cantilever method.

[0040] The nonwoven fabric of the present invention includes nonwoven fabrics comprising the polyester staple fibers of the present invention mixed with staple fibers other than the polyester staple fibers of the present invention and nonwoven fabric laminate comprising at least one nonwoven fabric layer comprising the polyester staple fibers of the present invention and at least one additional nonwoven fabric layer comprising staple fibers other than those of the present invention, laminated on each other.

[0041] Particularly, the nonwoven fabric formed from the polyester staple fibers of the present invention alone exhibits a specific soft hand other than that of the nonwoven fabric comprising the conventional polyester staple fibers, and thus is preferred in various uses.

[0042] In the polyester staple fibers of the present invention, 50% or more of the peripheral surface area of individual staple fibers are formed from the specific polymeric blend of a polyester polymer with 0.5 to 15% by mass of a polyolefinic polymer. This feature of the present invention enables the resultant staple fibers to exhibit a reduced friction between the fibers and thus an enhanced fiber-opening property and therefore, the resultant nonwoven fabric to exhibit a soft hand and a high uniformity in texture thereof.

[0043] The mechanism of realizing the effects of the polyester staple fibers and the nonwoven fabric of the present invention has not yet be completely clear. However, it is assumed that in the polymeric blend usable for the present invention, the polyolefinic polymer is incompatible with the polyester polymer and thus when an appropriate amount of the polyolefinic polymer is mixed and dispersed in a matrix consisting of the polyester polymer, the polyolefinic polymer is suspended in the form of a plurality of islands located in a sea consisting of the matrix polyester polymer, and when individual fibers are formed by using the polymeric blend, a portion of the islands appears on at least a portion of the peripheral surface of each of the individual fibers so as to roughen the peripheral surface, and thus the resultant individual fibers are mainly contacted with each other at the convexed portions of the peripheral surfaces of the fibers and exhibit a low frictional coefficient with each other.

EXAMPLES

[0044] The present invention will be further illustrated by the following examples.

[0045] In the examples and comparative examples, the resultant staple fibers and nonwoven fabrics were tested in the items and by the measurement methods as shown below.

[0046] (a) Fiber Thickness

[0047] The thickness of fibers was determined in accordance with JIS L 1015-1992, 7.5.1, Method A.

[0048] (b) Fiber Length

[0049] The length of staple fibers was determined in accordance with JIS L 1015-1992, 7.4.1, Direct Method (method C).

[0050] (c) The Number of Crimps and Percentage of Crimps

[0051] The number and percentage of crimps of crimped staple fibers were determined in accordance with JIS L 1015-1992, 7.12.

[0052] (d) Intrinsic Viscosity of Polyester Polymer

[0053] The intrinsic viscosity ([η]) of polyester polymer was measured in orthochlorophenol at a temperature of 35° C.

[0054] (e) Melt Index (MFR) of Polyester Polymer or Polyolefinic Polymer

[0055] The MFR of polyester polymer on polyolefinic polymer was measured in accordance with JIS K 7210, under condition 4.

[0056] (f) Glass Transition Temperature (Tg) and Melting Temperature (Tm) of Polyester Polymer or Polyolefinic Polymer

[0057] The glass transition temperature (Tg) and melting temperature (Tm) of polyester polymer or polyolefinic polymer was measured by using a differential scanning calorimeter (model: DSC-7, made by Parkin-Elmer Co.) at a temperature-increasing rate of 20° C./minute.

(g) Degree of Crystallinity of Fibers

[0058] The degree of crystallinity of fibers was determined by measuring a density ρ in g/cm^3 of a fiber using a density-gradient tube containing a mixture of n-heptane with carbon tetrachloride at a temperature of 25° C., and calculating it from the resultant density ρ of the fiber in accordance with the following equation.

$$xc=\rho c(\rho-\rho a)/\rho(\rho c-\rho a)$$

wherein xc represents a degree of crystallinity, in % by mass, of the fibers, ρc represents a crystal density of polyethylene terephthalate, namely 1.455 g/cm^3, pa represents an amorphous density of polyethylene terephthalate, namely 1.335 g/cm^3, and p represents the density of the fibers.

[0059] (h) Birefringence (Δn) of Fibers

[0060] The birefringence (Δn) of fibers was determined by a retardation method using, as an immersion liquid, bromonaphthalene and a Belec compensator, as disclosed in W. E. Morton and J. W. S. Hearle, "Physical Properties of Textile Fibers", page 524 to 532, 22.2.1 Refractive Index and birefringence to 22.2.3 Measurement of birefringence, published by the Textile Institute Butter Worths, Manchester & London.

[0061] (i) Percentage (u) of Non-Opened Fibers

[0062] Non-opened fiber lumps were taken-up from 10 g of a web produced by the air laid method, the mass (x) of the taken-up fiber lumps was measured, and the percentage (u) of the non-opened fibers in the web was calculated in accordance with the following equation.

$$u(\%)=x/10\times 100$$

wherein x represents a mass of the non-opened fiber lumps taken-up from the web and u represents a percentage of the non-opened fibers in the web.

[0063] (j) Resistance of Non-Woven Fabric to Bending

[0064] The bending resistance of the nonwoven fabric was measured in accordance with JIS L 1085-1992, 5.7. Method A (45° cantilever method). The lower the number, the higher the softness of the fabric.

[0065] (k) Evaluation of Woven Fabric Texture

[0066] The appearance of the woven fabric was observed by the naked eye and evaluated in the following three classes.

Class	Fabric texture
3	No non-opened fiber lump is found. No unevenness in mass distribution is found. Texture of fabric is uniform.
2	Non-opened fiber lumps appear to be not significant. Uneven mass distribution is found by naked eye observation.
1	Non-opened fiber lumps are significant. Uneven mass distribution is significant. The fabric texture is not uniform.

Example 1

[0067] Polyethylene terephthalate (PET) pellets dried under vacuum at 120° C. for 16 hours and having an intrinsic viscosity [η] of 0.61 and a melting temperature (Tm) of 256° C. and high density polyethylene (HDPE) pellets having a melt index (MFR) of 20 g/10 minuets and a melting temperature (Tm) of 131° C. were mixed with each other in a mass ratio of 97:3. The mixture was melted in a twin-screw extruder and the resultant melt having a temperature of 280° C. was extruded through a (melt)-spinneret having 600 spinning round orifices having an inner diameter of 0.3 mm at an extruding rate of 200 g/minute. The extruded filamentary melt streams were cooled with cooling air at a temperature of 30° C. and the cooled and solidified undrawn multifilament yarn was wound up at a speed of 1150 m/minute. The undrawn multifilament yarn was subjected to a crimping procedure using a stuffing box type crimper, to impart plane zigzag-formed crimps with the number of crimps of 8 crimps/25 mm and a percentage of crimps of 4% to the undrawn individual filaments of the multifilament yarn. The crimped multifilament yarn was oiled with 0.25% by dry mass, based on the dry mass of the yarn, of an oiling agent comprising an alkylphosphate potassium salt and a polyoxyethylene-modified silicone in a mass ratio of 80/20, and dried by blowing hot air at a temperature of 45° C. The dried undrawn multifilaments were cut into a fiber length of 5 mm. The resultant polyester staple fibers had a thickness of 3.1 dtex, a degree of crystallinity of 16% and a birefringence of 0.0035.

[0068] The staple fibers were subjected to an air laid web-forming procedure to provide a web having a basis mass of 50 g/m^2. The web was subjected to a calendering procedure using a pair of flat calender rollers having a roller surface temperature of 200° C. under a linear pressure of 80 kPa·m at a speed of 20 m/minute, to prepare an air laid nonwoven, fabric. The nonwoven fabric had a bending resistance of 50 mm, a percentage (u) of non-opened fibers of 0.5% and a texture of the nonwoven fabric in class 3.

Example 2

[0069] Polyester staple fibers and an air laid nonwoven fabric were produced by the same procedures as in Example 1, except that the PET was replaced by a polyethylene terephthalate isophthalate copolymer containing 10 molar % of copolyesterified isophthalic acid and having a melting temperature of 220° C. The resultant polyester staple fibers had a thickness of 3.4 dtex, a degree of crystallinity of 9%, and a birefringence of 0.0027. The resultant nonwoven fabric had a bending resistance of 44 mm, a percentage (u) of non-opened fibers of 0.8% and a nonwoven fabric texture in class 3.

Example 3

[0070] Pellets of an amorphous polyethylene terephthalate isophthalate copolymer containing 40 molar % of copolymerized isophthalic acid dried under vacuum at 50° C. for 24 hours and having an intrinsic viscosity [η] of 0.55 and a glass transition temperature (Tg) of 65° C. and pellets of a high density polyethylene (HDPE) having a melt index (MFR) of 20 g/10 minuets and a melting temperature (Tm) of 131° C. were mixed with each other in a mass ratio of 95:5. The mixture was melted in a twin-screw extruder to prepare a polymeric blend melt having a temperature of 250° C. Separately, pellets of a PET dried at a temperature of 120° C. for 16 hours and having an intrinsic viscosity [η] of 0.61 were melted in an extruder to prepare a PET melt having a temperature of 280° C.

[0071] The polymeric blend melt and the PET melt were subjected to a melt spinning procedure using a concentric core-in-sheath type conjugate filament-forming spinneret having 1032 spinning orifices having an inner diameter of 0.3 mm for forming core-in-sheath type composite filaments having sheath portions formed from the polymeric blend melt and a core portions formed from the PET melt in a cross sectional area ratio (A/B) of the sheath portions (A) to the core portions (B) of 50:50.

[0072] The core-in-sheath type conjugate streams of the polymeric blend melt and the PET melt were extruded through the spinneret at a spinneret temperature of 285° C. at a extruding rate of 870 g/minute, and cooled by blowing cooling air at a temperature of 30° C. The resultant undrawn core-in-sheath type conjugate multifilament yarn was wound up at a speed of 1150 m/minute. The undrawn conjugate multi filament yarn was drawn in hot water at a temperature of 80° C. at a draw ratio of 3.75, then the drawn conjugate multifilament yarn was passed through a water bath at a temperature of 30° C. to cool the yarn and to prevent the fuse adhesion of the drawn individual filaments to each other, the cooled yarn was oiled with 0.2% by dry mass of an oiling agent comprising an alkylphosphate potassium salt and a polyoxyethylene-modified silicone in a mixing dry mass ratio of 80:20. The oiled yarn was crimped in a stuffing box type crimper to impart plane zigzag-formed crimps in the number of crimps of 9 crimps/25 mm and a percentage of crimps of 12%, to the individual conjugate filaments. The crimped filaments were dried at a temperature of 50° C. and cut into a fiber length of 5 mm. The resultant staple conjugate fibers had a thickness of 2.1 dtex.

[0073] The staple conjugate fibers were subjected to an air laid web-forming procedure to provide a web having a basis mass of 50 g/m^2. The web was subjected to a heat-bonding procedure using a hot air blow at a temperature of 150° C. for 2 minutes to cause the individual staple conjugate fibers to adhere at portions thereof crossing each other. The resultant air laid nonwoven fabric had a bending resistance of 53 mm, a percentage of non-opened fibers of 0.7% and a texture of the nonwoven fabric in class 3.

Comparative Example 1

[0074] Polyester staple composite fibers and an air laid nonwoven fabric were produced by the same procedures as in Example 3, except that the polymeric blend of the amorphous PET copolymer with HDPE for the sheath portions of the conjugate fibers was replaced by an amorphous polyethylene terephthalate isophthalate copolymer containing 40 molar % of copolymerized isophthalic acid and having an intrinsic viscosity [η] of 0.55 and Tg of 65° C. The resultant staple conjugate fibers had a thickness of 2.1 dtex. The resultant nonwoven fabric had a bending resistance of 83 mm, a percentage of non-opened fibers of 11% and a nonwoven fabric texture in class 1.

Comparative Example 2

[0075] A polymeric blend for the sheath portions of the core-in-sheath type conjugate filaments was prepared by the same manner in Example 3, except that a mixing ratio of the amorphous PET copolymer pellets to the HDPE was changed from 95:5 to 84:16. The resultant polymeric blend exhibited a poor filament-forming property and thus the melt-spinning procedures could not be carried out.

Example 4

[0076] Polyester staple fibers and a nonwoven fabric were produced by the same procedures as in Example 3, with the following exceptions. In the polymeric blend for the sheath portions of the conjugate filaments, the HDPE was replaced by an isotactic polypropylene resin having an MFR of 30 g/10 minutes and a Tm of 160° C.

[0077] The resultant staple conjugate fibers had a thickness of 2.2 dtex. The resultant nonwoven fabric had a bending strength of 58 mm, a percentage of non-opened fibers of 1.3% and a nonwoven fabric texture in class 3.

Example 5

[0078] Polyester staple fibers and a nonwoven fabric were produced by the same procedures as in Example 3, with the following exceptions.

[0079] In the polymeric blend for the sheath portions of the conjugate filaments, the HDPE was replaced by an ethylenepropylene random copolymers in a copolymerization molar ratio of ethylene to propylene of 37:63 and having an MFR of 50 g/10 minutes and a Tm of 135° C.

[0080] The resultant staple conjugate fibers had a thickness of 2.2 dtex.

[0081] The resultant nonwoven fabric had a bending resistance of 58 mm, a percentage of non-opened fibers of 1.3% and a nonwoven fabric texture in class 3.

Example 6

[0082] Polyester staple fibers and a nonwoven fabric were produced by the same procedures as in Example 3, with the following exceptions.

[0083] In the polymeric blend for the sheath portions of the conjugate filaments, the HDPE was replaced by a straight linear low density polyethylene graft-copolymerized with 3.5% by mass of maleic anhydride and having an MFR of 8 g/10 minutes and a Tm of 96° C.

[0084] The resultant staple conjugate fibers had a thickness of 2.2 dtex.

[0085] The resultant nonwoven fabric had a bending resistance of 52 mm, a percentage of non-opened fibers of 0.8% and a nonwoven fabric texture in class 3.

Example 7

[0086] Polyester staple fibers and a nonwoven fabric were produced by the same procedures as in Example 3, with the following exceptions.

[0087] The PET for the core portions of the conjugate filaments was replaced by nylon 6 having an intrinsic viscosity of 1.34, determined in metacresol at a temperature of 35° C. and a Tm of 215°c. Chips of the nylon 6 were melted in an extruder to prepare a nylon 6 melt having a temperature of 240° C. The melt-spinning for the core-in-sheath type conjugate filaments was carried out at a spinneret temperature of 250° C. at an extruding rate of 500 g/minute. The resultant undrawn multifilament yarn was drawn at a draw ratio of 2.1 at room temperature and then at a draw ratio of 1.05 in hot water having a temperature of 55° C. The drawn multifilament yarn was passed through a water bath to cool it and then oiled in the same manner as in Example 3. The oiled multifilament yarn was crimped with plane zigzag-formed crimps in the number of crimps of 12 crimps/25 mm and in a percentage of crimps of 6.5% and then dried at a temperature of 45° C. The crimped multifilaments were cut into staple fibers in the same manner as in Example 3.

[0088] The resultant staple conjugate fibers had a thickness of 2.2 dtex.

[0089] The resultant nonwoven fabric had a bending resistance of 57 mm, a percentage of non-opened fibers of 1.6% and a nonwoven fabric texture in class 3.

Example 8

[0090] Polyester staple fibers and a nonwoven fabric were produced by the same procedures as in Example 3, except that the staple fiber length was changed from 5 mm to 3 mm.

[0091] The resultant nonwoven fabric had a bending resistance of 57 mm, a percentage of non-opened fibers of 1.6% and a nonwoven fabric texture in class 3.

Example 9

[0092] Polyester staple fibers and a nonwoven fabric were produced by the same procedures as in Example 3, except that the concentric core-in-sheath type conjugate filament-forming spinneret was replaced by an eccentric core-in-sheath type conjugate filament-forming spinneret, the percentage of the crimps on the crimped fibers was changed from 12% to 15%, and the crimps had an omega (w) form.

[0093] The resultant staple conjugate fibers had a thickness of 2.3 dtex.

[0094] The resultant nonwoven fabric had a bending resistance of 55 mm, a percentage of non-opened fibers of 0.9% and a nonwoven fabric texture in class 3.

Example 10

[0095] Polyester staple fibers and a nonwoven fabric were produced by the same procedures as in Example 3, except that no crimping was applied to the drawn composite multifilament yarn.

[0096] The resultant nonwoven fabric had a bending resistance of 53 mm, a percentage of non-opened fibers of 0.2% and a nonwoven fabric texture in class 3.

Example 11

[0097] Polyester staple fibers prepared by the same procedures as in Example 10 and wood pulp fibers in a mass ratio of 80:20 were suspended in water, while fully stirring, and a sheet having dimensions of about 25 cm×about 25 cm and a dry basis mass of 50 g/m^2 was prepared from the aqueous mixed fiber slurry by using a square-shaped sheet-forming machine. The sheet was dried at room temperature over 24 hours or more, then placed on a perforated polytetrafluoroethylene sheet and subjected to a shrinking treatment in a hot air-circulation type dryer at a temperature of 120° C. for 5 minutes, to produce a wet laid method nonwoven fabric.

[0098] The resultant nonwoven fabric had a bending resistance of 38 mm and a nonwoven fabric texture in class 3.

Comparative Example 3

[0099] Polyester staple fibers and a wet laid method nonwoven fabric were produced by the same procedures as in Example 11, except that the crimping procedure for the drawn multifilament yarn was omitted.

[0100] The resultant nonwoven fabric had a bending resistance of 38 mm and a nonwoven fabric texture in class 2.

Example 12

[0101] Polyester staple fibers were produced by the same procedures as in Example 3, except that fiber length of the staple fibers was changed from 5 mm to 51 mm.

[0102] The staple fibers were fed to a carding procedure using a roller carding machine to prepare a card web. In the carding procedure, the staple fibers exhibited a good carding machine-passing property. A plurality of card webs were superposed on each other to prepare a laminated web having a basis mass of 50 g/m^2.

[0103] The laminated web was subjected to the same heat-bonding procedure as in Example 3 using hot air streams to heat-bonding the staple fibers at crossing portions thereof to each other. A carding method heat-bonding nonwoven fabric.

[0104] The resultant nonwoven fabric had a bending resistance of 58 mm and a nonwoven fabric texture in class 3.

Example 13

[0105] Polyester staple fibers were produced by the same procedures as in Example 10, except that fiber length of the staple fibers was changed from 5 mm to 51 mm.

[0106] The staple fibers were fed to the same carding procedure as in Example 12 to prepare a card web. In the carding procedure, the staple fibers exhibited a good carding machine-passing property. A plurality of card webs were superposed and heat-bonding in the same manner as in Example 12 to produce a card method heat-bonding nonwoven fabric.

[0107] The resultant nonwoven fabric had a bending resistance of 51 mm and a nonwoven fabric texture in class 3.

[0108] The present invention can provide specific polyester staple fibers useful for forming a nonwoven fabric having a soft hand and a uniform texture. Also, the present invention can provide a nonwoven fabric having not only a uniform texture but also a soft hand. Especially, the nonwoven fabric produced from a web formed from the polyester staple fibers of the present invention by an air laid web-forming method has a very low percentage of non-opened fibers and an excellent uniformity of texture.

[0109] Accordingly, the specific polyester staple fibers enable the resultant nonwoven fabric produced from the staple fibers to have widened various uses and thus have a high industrial value.

1-12. (canceled)

13. A process for producing a nonwoven polyester staple fiber fabric comprising;

preparing polyester staple fibers comprising a polymeric blend comprising 85 to 95.5% by mass of matrix polyester polymer and 0.5 to 15% by mass of a polyolefinic polymer mixed with and dispersed in the matrix polyester polymer, at least the surface of each fiber being formed by the polymeric blend; and

forming the polymeric blend staple fibers into a nonwoven fabric by an air-laid web-forming method.

14. The process for producing a nonwoven polyester staple fiber fabric as claimed in claim 13, wherein the polyolefinic polymer comprises at least one member selected from polyethylene, polypropylene, ethylene-propylene copolymers and polyethylene copolymers and polypropylene copolymers in which at least one ethylenically unsaturated monomer different from ethylene and propylene is block-copolymerized or graft-copolymerized.

15. The process for producing a nonwoven polyester staple fiber fabric as claimed in claim 13, wherein the matrix polyester polymer is selected from polyalkylene terephthalates and polyalkylene terephthalate-isophthalate copolymers.

16. The process for producing a nonwoven polyester staple fiber fabric as claimed in any one of claims 13 to 15, wherein the polyester staple fibers have a degree of crystallization of 20% or less or a birefringence of 0.05 or less.

17. The process for producing a nonwoven polyester staple fiber fabric as claimed in any one of claims 13 to 15, wherein the polyester staple fibers have a concentric or eccentric core-in-sheath conjugate structures in which the sheath section is formed from the polymeric blend, and core section is formed from a member selected from polyesters and polyamides.

18. The process for producing a nonwoven polyester staple fiber fabric as claimed in any one of claims 13 to 15, wherein the polyester staple fibers have a fiber length of 2 to 30 mm, and crimps in a number of crimp of 3 to 13 crimps/25 mm and a percentage of crimp of 3 to 15%.

19. The process for producing a nonwoven polyester staple fiber fabric as claimed in any one of claims 13 to 15, wherein the nonwoven fabric has a percentage of non-opened fibers of 5% or less.

20. The process for producing a nonwoven polyester staple fiber fabric as claimed in any one of claims 13 to 15, wherein the nonwoven fabric has a bending resistance of 70 mm or less, as determined by the cantilever method.

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