

Title of the Invention

Nonwoven Fabric and Process for
Producing the Same

Background of the Invention

Field of the Invention

This invention relates to a nonwoven fabric and a process for producing the same. Especially, this invention relates to a spunbonded nonwoven fabric which exhibits an excellent elongation as well as a well balanced tensile strength in machine and transverse directions, which may be adequately used for an agricultural sheet, packaging material, medical/sanitary material, and the like, and also relates to a process for producing the same.

Description of the Related Art

Spunbonded nonwoven fabrics may be classified into those wherein the fabric has been prepared by spinning a filament, drawing the filament by a round-type or slit-type air gun, and distributing the filament by a distributing apparatus to lay the filament on a mesh belt; and those wherein the fabric has been prepared by spinning a filament, air-cooling the filament in a pressurized chamber to draw the filament through the nozzle as the filament is discharged from the pressurized chamber, and distributing the filament on a mesh belt. In the production of the spunbonded nonwoven fabric by such methods, the filaments are taken off at a speed as high as 2,000 to 6,000 m/min and at a draft ratio as high as 500 to 1,000 for the

purpose of fulfilling the required productivity, and the thus produced nonwoven fabric usually exhibits a ratio of tensile strength in machine direction to the tensile strength in transverse direction of 2 or more and poor elongation as well.

Such spunbonded nonwoven fabrics have been widely used as an agricultural sheet, a packaging material, a medical/sanitary material such as surgical gown or disposable diapers, kitchen drain bag, or the like.

Such spunbonded nonwoven fabrics are required to have different properties depending on their use. For example, an agricultural spunbonded nonwoven fabric sheet is used for protecting the crop from frost and harmful insects by covering the crop with the nonwoven fabric sheet. In covering the crop with the nonwoven fabric sheet, the sheet is spread out as the sheet is outwardly from opposite side edges in transverse direction. Conventional nonwoven fabric sheets were insufficient in their tensile strength in transverse direction, and therefore, tear in axial direction often occurred during the work of spreading out the sheet, resulting in poor working efficiency.

The spunbonded nonwoven fabric sheets used for packaging purpose are also susceptible to tearing in axial direction as in the case of the agricultural spunbonded nonwoven fabric sheets since tensile force in transverse direction is applied to the sheet in the course of the packaging. The spunbonded nonwoven fabric sheets used for packaging purpose also suffered from an insufficient heat

sealability, and therefore, it was rather difficult to fabricate a laundry bag or other clothing bag, or a kitchen drain bag from such sheet material.

Improvement in tensile strength in transverse direction of the spunbonded nonwoven fabric material is also required for use in medical and sanitary fields since improvement in tear resistance is required for the final products such as surgical gowns and diapers that are produced from the spunbonded nonwoven fabric material.

A method for improving tear resistance against tensile force in transverse direction of a spunbonded nonwoven fabric is disclosed in Japanese Patent Application Laid-Open No. 5(1993)-195403, wherein the tear resistance is improved by improving the strength in transverse direction. However, such improvement only in the strength in transverse direction proved to be insufficient in fully improving the tear resistance of the nonwoven fabric.

SUMMARY OF THE INVENTION

First object of the present invention is to provide a spunbonded nonwoven fabric which has an improved tear resistance against the tensile force applied in transverse direction.

Second object of the present invention is to provide a spunbonded nonwoven fabric that exhibits an excellent elongation as well as a well balanced tensile strength in machine and transverse directions, which is adequate for use as an agricultural sheet, packaging material,

industrial material, medical/sanitary material, and the like in various fields.

Third object of the present invention is to provide a process that is capable of producing a spunbonded nonwoven fabric as described above having excellent properties.

In order to attain the above-described first and second objects, there is provided by the present invention a nonwoven fabric prepared by a spunbond method from polyolefin, having a ratio of tensile strength in machine direction to transverse direction in the range of from 0.5 to 1.5, and an elongation in transverse direction of at least 60%.

To attain the third object, there is provided by the present invention a process for producing the nonwoven fabric by a spunbond method from polyolefin, comprising the steps of spinning a filament and drawing the filament at a take off speed of 500 to 2,000 m/min and at a draft ratio of from 100 to 500; and forming a web of the nonwoven fabric by using the drawn filament.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of an exemplary system for producing the nonwoven fabric of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In order to attain the above-described objects, the inventors have conducted a series of experiments to improve the production process of a spunbonded nonwoven fabric

comprising the steps of extruding a molten polyolefin resin from a spinneret to form filaments; drawing and bundling the filaments by a take-off apparatus; uniformly distributing the filaments by a distributing apparatus and depositing on a collecting belt to form a web of the filaments; and spot fusing or entangling the filaments to thereby produce the nonwoven fabric. After such an extensive investigation, the inventors of the present invention found that a nonwoven fabric having a well balanced tensile strength in machine and transverse directions having a ratio of tensile strength in machine direction to transverse direction of from 0.5 to 1.5 may be produced by limiting the speed of the filament taken off by the take off apparatus to a particular range, since the filament drawn at such take off speed is likely to be oriented also in transverse direction by the distributing apparatus.

The present invention has been completed on the basis of such findings, and the amount of the molten resin at 200 to 300°C extruded per single nozzle (amount of the molten resin extruded per one nozzle in the spinneret) is adjusted to enable the filament to be taken off at a speed of from 500 to 2,000 m/min, preferably from 1,000 to 2,000 m/min, and more preferably from 1,000 to 1,500 m/min. The amount w of the molten resin extruded per single nozzle; the take off speed V_f (m/min) of the filament in the take off apparatus; and fineness d (denier) of the filament has the following relationship:

$$V_f = 9,000 \times w/d$$

In the present invention, the filament take off speed is limited to the above-specified range and the draft ratio is adjusted to the range of from 100 to 500, and preferably from 200 to 400 to thereby produce a nonwoven fabric wherein the monofilament exhibits an elongation of at least 400%, and the fabric exhibits a ratio of tensile strength in machine direction to transverse direction of from 0.5 to 1.5 and an elongation in transverse direction of at least 60%.

In addition to the well balanced tensile strength in machine and transverse directions and the improved elongation, the nonwoven fabric of the present invention has an improved heat sealability since the degree of crystallization of the resin constituting the filament is low due to the low draft ratio in the range of from 100 to 500 compared to the conventional nonwoven fabric that had been prepared by drawing the filaments at a draft ratio of from 500 to 1,000.

Furthermore, since the nonwoven fabric of the present invention has been prepared by drawing the filaments at a draft ratio of 100 to 500, a monofilament elongation as high as 400% or more is attained. The monofilament elongation may be increased to 500% or more by drawing the filaments at a draft ratio of 100 to 400. The elongation of the nonwoven fabric is correspondingly increased, and the nonwoven fabric may exhibit an elongation in transverse direction of 60% or more, and preferably 70% or more, and

more preferably 80% or more. As a result, the nonwoven fabric is less likely to experience tear in machine direction. It should be noted that the term "draft ratio" used herein designates the ratio of the resin (linear) speed at the exit of the nozzle to the filament take off speed.

The nonwoven fabric of the present invention may be prepared by using a polyolefin, which may consist of alone or in combination of two or more α -olefin such as ethylene, propylene, and 1-butene. Typical α -olefin polymer is a polypropylene. The polypropylene includes a propylene homopolymer and copolymer of propylene and the other α -olefin. These polyolefin may be used alone or in combination of two or more.

The weight per unit area of the nonwoven fabric of the present invention and the fineness of the filament used for constituting the nonwoven fabric are generally in the range of from 10 to 150 g/m² and from 1 to 25 denier, respectively, although they may vary according to the application of the nonwoven fabric. In the case of the nonwoven fabric for agricultural sheet, the areal weight of the nonwoven fabric may be limited to the range of from 15 to 30 g/m², and the fineness of the filament may be limited to the range of from 5 to 15 denier in view of light transmittance and water permeability. In the case of the nonwoven fabric for medical/sanitary material, the areal weight of the nonwoven fabric may be limited to the range of from 10 to 30 g/m², and the fineness of the filament may

be limited to the range of from 1 to 4 denier in view of water resistance and flexibility.

The nonwoven fabric of the present invention may be prepared by using the spunbond system illustrated in FIG. 1. In the production system shown in FIG. 1, the molten polyolefin fed to the spinning apparatus 1 is extruded from nozzles of a spinneret 2 to form filaments 3. The filaments 3 are drawn by a take off apparatus 4 having an air gun. The thus drawn filaments 3 are continuously distributed by a distributing apparatus 5 and deposited onto a collecting belt 6 comprising a mesh belt, where the web of the nonwoven fabric is formed. The collecting belt is driven in the direction of the arrow A by means of driving rolls 7a and 7b, and the filament web is transferred to a fusing/entangling apparatus 8. In the fusing/entangling apparatus 8, the web is spot fused or entangled to produce the nonwoven fabric 9 of the present invention.

In such production system, the take off apparatus 4 may typically comprise an air gun of slit type or rounded type, and the distributing apparatus 5 may comprise distributing plate of rocking type or secured type, or a distributing apparatus of air spray type. The mesh belt constituting the collecting belt 6 may comprise a resin belt or a metal belt. The fusing/entangling apparatus 8 may comprise a spot fusing machine having an embossing roll, a needle punching machine, or alternatively, the

filament web may be bonded by using a high pressure fine jet of water or hot air.

As described above, the nonwoven fabric of the present invention has a high tear resistance against tensile force in transverse direction, an excellent elongation, and a well balanced tensile strength in machine and transverse directions. In view of such advantageous properties, the nonwoven fabric of the present invention may be used for a padding of men's, women's and children's clothing such as shirt and coat; a thermal insulator for heavy winter clothing, nightgown and quilted clothing; a material for fabricating disposable clothing such as protective clothing or underwear; a material for fabricating bed linens such as blanket, sheet, bed cover, quilt and cushion; an interior material for carpet, curtain, and wall paper; a material for audio equipment and sheet of a furniture; a material for parts of shoes and boots such as vamp, lining, insole, toe puff, boot lining, and reinforcement; a material for parts of bags such as lining, strap puff, and packing; a filter for liquids, gases, and dust collection; a material for wipers such as lint free and various wiper cloths; an insulator material for electronic device such as separator and liner for tape, cell, coil, and floppy disk; a substrate for printed matter such as map, calendar, label, tag, envelope, stencil; a material for packaging such as envelope, shopping bag, and packages for sweets and tea; an industrial material such as abrasives, oil adsorbents, substrate for synthetic leather, and substrate for various

adhesive tapes; a civil engineering material such as asphalt overlay, soil stabilizer, filtering material, underliner for water storage, erosion preventive, quick sand preventive, reinforcement, vegetation mat, concrete curing sheet, and artificial turf; a building material such as roofing material, floor material, insulator, and backing; an agricultural/horticultural material such as heat sealing material, windshield material, shading material, fruit protecting material, crop protecting material, seedling raising material, sowing bed, frost protecting material, heat insulation material, insect/bird protective material, and various plant covers; a material for wrapping sweets, tea, pillow, and gloves; a kitchen/laundry commodity such as bath towel, face towel, table cloth, apron, and cleaning softener; a cosmetic wiper such as cosmetic puff, gauze, shoeshine cloth, and floor wiping cloth; a material for daily commodities such as various blotting papers, hobby goods, toiletry goods, kitchen goods, book cover, tent, calendar, stationery, and the like; a medical material for hospital supplies, for example, surgical mask, gown and cap, CSR wrap, underpad, package, gauze, bed sheet, bandage, eye bandage, surgical tape, and shroud; and a pharmaceutical material such as substrate for cataplasmata, mask for hay fever and adhesive tape; and a sanitary material for sanitary napkin, shield of sanitary brief and other sanitary items, diapers for adults and babies, and padding for incontinence.

SPECIFIC EXAMPLES OF THE INVENTION

The present invention is described in further detail by referring to Examples of the invention and Comparative Examples, which by no means limit the scope of the present invention.

In the Examples and Comparative Examples, elongation of the monofilament, tensile strength of the nonwoven fabric, and heat sealability of the nonwoven fabric were evaluated by the procedure as described below.

Elongation of monofilament

Elongation of monofilament was evaluated on a tensile testing machine having a pair of chucks positioned at an interval of 20 mm by mounting the filament between the chucks. Tensile test was conducted at room temperature at a test speed of 100 mm/min to determine the elongation at break.

Tensile test of nonwoven fabric

Samples of the nonwoven fabric of 200 mm x 50 mm were prepared and the sample was mounted between the chucks of a tensile testing machine having a pair of chucks positioned at an interval of 100 mm. Tensile test was conducted at room temperature at a test speed of 300 mm/min to determine the tensile strength. The nonwoven fabric samples were measured for both machine direction and transverse direction.

Heat sealability of the nonwoven fabric

Samples of the nonwoven fabric were heat sealed by a heat sealing machine at a sealing temperature of 400°C to

evaluate the heat sealability of the sample according to the following criteria:

O: excellent

Δ: fair

X: poor.

Example 1

Using the production system of FIG. 1, continuous filaments of molten propylene homopolymer (MFR (ASTM D1238, 230°C, under the load of 2.16 kg): 35 g/10 min.) at a resin temperature of 223°C was extruded from the spinning machine equipped with the spinneret with 756 nozzles each having a diameter of 0.85 mm at an extrusion rate/nozzle of 1.41 g/min. The filaments were drawn by the draft apparatus at a take off speed of 1,200 m/min and at a draft ratio of 400, and the thus drawn filaments were fed to the distributing apparatus to air-lay the filaments on the mesh belt to thereby form the web of the filaments. The filament web on the mesh belt was transferred to the bonding/entanglement apparatus where the fiber web was spot-fused with an embossing roll having embossing area of 10% to thereby form a nonwoven fabric of 25 g/m².

The monofilament was evaluated for its elongation, and the resulting nonwoven fabric was evaluated for its tensile strength, elongation, and heat sealability. The results are shown in Table 1.

Example 2

A nonwoven fabric was prepared as in Example 1, except that the filaments were extruded from the spinneret with nozzles each having a diameter of 0.6 mm at an extrusion rate/nozzle of 1.04 g/min, and the filaments were drawn at a draft ratio of 270.

The monofilament was evaluated for its elongation, and the resulting nonwoven fabric was evaluated for its tensile strength, elongation, and heat sealability. The results are shown in Table 1.

Example 3

A nonwoven fabric was prepared as in Example 1, except that the filaments were extruded from the spinneret with nozzles each having a diameter of 0.85 mm at an extrusion rate/nozzle of 1.5 g/min, and the filaments were drawn at a take off speed of 1,000 m/min and at a draft ratio of 300.

The monofilament was evaluated for its elongation, and the resulting nonwoven fabric was evaluated for its tensile strength, elongation, and heat sealability. The results are shown in Table 1.

Comparative Example 1

A nonwoven fabric was prepared as in Example 1, except that continuous filaments of molten propylene homopolymer at a resin temperature of 234°C was extruded with the nozzles each having a diameter of 0.6 mm at an extrusion rate/nozzle of 0.59 g/min, and the filaments were drawn at a take off speed of 2,500 m/min and a draft ratio of 1,000.

The monofilament was evaluated for its elongation, and the resulting nonwoven fabric was evaluated for its tensile strength, elongation, and heat sealability. The results are shown in Table 1.

Comparative Example 2

A nonwoven fabric was prepared as in Example 1, except that continuous filaments of molten propylene homopolymer at a resin temperature was extruded with the nozzles having a diameter of 0.6 mm at an extrusion rate/nozzle of 0.40 g/min, and the filaments were drawn at a draft ratio of 700.

The monofilament was evaluated for its elongation, and the resulting nonwoven fabric was evaluated for its tensile strength, elongation, and heat sealability. The results are shown in Table 1.

Table 1

	<u>Exam- ple 1</u>	<u>Exam- ple 2</u>	<u>Exam- ple 3</u>	<u>Comp. Exam- ple 1</u>	<u>Comp. Exam- ple 2</u>
Filament take off speed, m/min	1,200	1,200	1,000	2,500	1,200
Draft ratio	400	270	300	1,000	700
<u>Filament</u>					
Elongation, %	470	550	620	280	300
<u>Nonwoven fabric</u>					
<u>Tensile strength</u>					
MD, kg/5 cm	2.5	2.8	2.2	7.2	4.3
TD, kg/5 cm	2.5	2.6	3.2	1.7	4.0
MD/TD ratio	1.00	1.08	0.69	4.24	1.08
<u>Elongation</u>					
MD, %	58	64	99	35	30
TD, %	79	90	128	41	42
Heat sealability	Δ	0	0	X	X
Areal weight, g/m ²	25	25	25	25	25
Fineness, denier	10	8	12	2	3

MD: machine direction, TD: transverse direction.

As described above, the nonwoven fabric of the present invention is highly tear resistant to tensile force applied in transverse direction, and has an excellent elongation as well as a well balanced strength in machine and transverse directions. In view of such properties, the nonwoven fabric of the present invention may be advantageously used in various fields as an agricultural sheet, a packaging material, an industrial material, a medical/sanitary material, or the like. For

example, use of the nonwoven fabric of the present invention for an agricultural sheet will lead to an improved working efficiency upon spreading out of the sheet over the crop since no excessive care should be taken for preventing the sheet tearing in machine direction. Use of the nonwoven fabric of the present invention for a packaging material will result not only in the prevention of tear upon application of tensile force in transverse direction but also in an improved heat sealability.

In addition, the process for producing the nonwoven fabric of the present invention is capable of producing a nonwoven fabric having excellent properties as described above.



Claims:

1. A nonwoven fabric prepared by spunbond method from polyolefin, having a ratio of tensile strength in machine direction to transverse direction in the range of from 0.5 to 1.5, and an elongation in transverse direction of at least 60%.

2. A process for producing a nonwoven fabric comprising the steps of

spinning a filament and drawing the filament at a take off speed of 500 to 2,000 m/min and at a draft ratio of from 100 to 500; and

forming a web of the nonwoven fabric by using the drawn filament.

3. A process for producing a nonwoven fabric according to claim 2 wherein said filament is drawn at a take off speed of 1,000 to 1,500 m/min and at a draft ratio of from 100 to 400.

4. A nonwoven fabric produced by the process of claim 2 having a ratio of tensile strength in machine direction to transverse direction in the range of from 0.5 to 1.5, and an elongation in transverse direction of at least 60%.

5. A nonwoven fabric produced by the process of claim 2 having a ratio of tensile strength in machine direction to



transverse direction in the range of from 0.5 to 1.5, wherein each filament has an elongation of at least 400%.

6. An agricultural sheet comprising the nonwoven fabric according to claim 1, 4 or 5.

7. A packaging material comprising the nonwoven fabric according to claim 1, 4 or 5.

8. An industrial material comprising the nonwoven fabric according to claim 1, 4 or 5.

9. A medical/sanitary material comprising the nonwoven fabric according to claim 1, 4 or 5.