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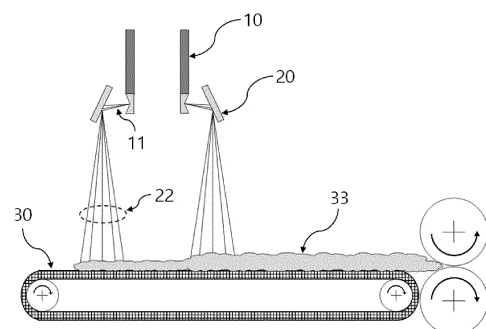
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(54) **SPUNBOND NON-WOVEN FABRIC WITH IMPROVED OPENING QUALITY AND NO HAZARDOUS RESIDUE, AND MANUFACTURING METHOD AND APPARATUS THEREOF**

(57) The present invention relates to a spunbond nonwoven fabric with improved opening quality and no hazardous residue, a manufacturing method thereof, and a manufacturing apparatus thereof. The method for manufacturing a spunbond nonwoven fabric according to the present invention includes a step of allowing the continuous filament bundle to collide with a metal member containing bismuth (Bi) or a bismuth alloy to obtain filaments opened by frictional charging.

[FIG. 1]



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Description**[TECHNICAL FIELD]**

5 **[0001]** The present invention relates to a spunbond nonwoven fabric with improved opening quality and no hazardous residue, a manufacturing method thereof, and a manufacturing apparatus thereof.

[BACKGROUND ART]

10 **[0002]** Generally, the manufacturing process of a spunbond nonwoven fabric is performed in the order of spinning, cooling, drawing, web formation, bonding, and winding. A spunbond process, which is performed via a continuous process, has high productivity and excellent economic efficiency.

[0003] The manufacturing process of the spunbond nonwoven fabric is divided into a Docan process and a Reicofil process according to the difference from spinning process to drawing process, and is subdivided according to the filament opening technology for forming a web.

15 **[0004]** According to the Reicofil process, the molten polymer discharged from a spinning pack having a rectangular structure is spun in the form of a filament curtain through a closed cooling/drawing section, which is subjected to separation by aerodynamic-force or a corona charging method to form a web. The Reicofil process has advantages that the production volume is high, the production speed is fast, and the nonwoven fabric manufacturing cost is low, and thus is applied to the field of sanitary materials, protective clothing, and filters that use olefin raw materials such as polyethylene and polypropylene. However, PET has difficulty in entering the high value-added market due to its low mechanical properties and appearance quality.

[0005] According to the Docan process, the molten polymer discharged from a spinning pack with a circular structure goes through an opened cooling/drawing section to form fibers in the form of a filament bundle, which are then subjected to opening by mechanical-force, electrostatic-charge, or a conjugate method to form a web. Under the Docan process, the nonwoven fabric has excellent mechanical properties and uniform appearance quality, so it is applied as a high value-added product. However, this has disadvantages that the production costs are high because the productivity is low compared to the Reicofil process.

25 **[0006]** Under the Docan process, various opening methods, such as a forced charging system by corona discharge and a frictional charging method by collision with a friction material (e.g., metal) have been developed. However, even if the opening property of the filament bundle is improved by the opening process, the areal density imbalance of the web (i.e., the non-uniformity of the weight per unit area of the web) still needs to be improved.

[0007] Meanwhile, a frictional charging process controls the performance according to the charging sequence of a friction material. For example, this process allows the polyester filaments to have a negative charge due to friction (collision) between polyester filaments and a metal plate material. The filaments are opened by Coulomb repulsive-force between the filaments having the same electric charge due to the friction.

[0008] Lead (Pb) is traditionally used as a metal plate material in the frictional charging process. However, since lead is soft, it is easily worn by friction with the filaments. Therefore, residual lead may be present in the spunbond nonwoven fabric manufactured by using lead as a friction material in the frictional charging process.

40 **[0009]** Lead (Pb) is one of the six hazardous substances according to the European Union's (EU) Restriction of Hazardous Substances Directive (RoHS), and has a potential risk that it is hazardous to human bodies. Therefore, lead (Pb) has a permissible limit value for each use of daily chemical materials, and furthermore, it is now recommended that lead is not used.

45 **[DETAILED DESCRIPTION OF THE INVENTION]**

[Technical Problem]

[0010] It is an object of the present invention to provide a method for manufacturing a spunbond nonwoven fabric with improved opening quality using a friction material that is not hazardous to human bodies while having a negative charge donation ability in the same level as that of lead (Pb).

[0011] It is another object of the present invention to provide an apparatus for manufacturing a spunbond nonwoven fabric.

55 **[0012]** It is yet another object of the present invention to provide a spunbond nonwoven fabric with improved opening quality and no hazardous residue.

[Technical Solution]

[0013] According to one embodiment of the present invention, there is provided a method for manufacturing a spunbond nonwoven fabric, the method including the steps of:

melt-spinning a thermoplastic resin to obtain a continuous filament bundle;
allowing the continuous filament bundle to collide with a metal member containing bismuth (Bi) or a bismuth alloy to obtain filaments opened by frictional charging; and
converging the opened filaments on a continuous conveyor net to form a fiber web.

[0014] According to another embodiment of the present invention, there is provided an apparatus for manufacturing a spunbond nonwoven fabric, the apparatus including:

a plurality of nozzle units configured and arranged so as to discharge a continuous filament bundle;
a collision unit that is adjacent to each of the nozzle units at a position for colliding with the continuous filament bundle jetted by the nozzle units; and
a continuous conveyor net that collects and conveys filaments opened by frictional charging with the collision unit, wherein the collision unit includes a collision surface that is a metal member containing bismuth (Bi) or a bismuth alloy.

[0015] According to yet another embodiment of the present invention, there is provided a spunbond nonwoven fabric which includes a fiber web containing thermoplastic resin filaments, and has a residual amount of bismuth (Bi) of 0.01 ppmw to 10.0 ppmw.

[0016] Now, a method for manufacturing a spunbond nonwoven fabric, an apparatus for manufacturing a spunbond nonwoven fabric, and a spunbond nonwoven fabric manufactured by using the above-mentioned apparatus will be described in more detail.

[0017] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. The terms used herein are for the purpose of describing specific embodiments only and are not intended to limit the scope of the invention.

[0018] The singular forms "a," "an," and "the" used herein are intended to include plural forms, unless the context clearly indicates otherwise.

[0019] It should be understood that the terms "comprise," "include," "have", etc. are used herein to specify the presence of stated features, regions, integers, steps, actions, elements, and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, actions, elements, components, and/or groups.

[0020] While the present invention can be modified in various ways and take on various alternative forms, specific embodiments thereof are illustrated and described in detail below. However, it should be understood that there is no intent to limit the present invention to the particular forms disclosed, but on the contrary, the present invention covers all modifications, equivalents, and alternatives falling within the spirit and scope of the present invention.

[0021] In describing a position relationship, for example, when the position relationship is described as 'upon~', 'above~', 'below~', and 'next to~', one or more portions may be arranged between two other portions unless 'just' or 'direct' is used.

[0022] In describing a time relationship, for example, when the temporal order is described as 'after~', 'subsequent~', 'next~', and 'before~', a case which is not continuous may be included unless 'just' or 'direct' is used.

[0023] The term "at least one" should be understood as including any and all combinations of one or more of the associated listed items.

I. Method for manufacturing spunbond nonwoven fabric

[0024] According to one embodiment of the present invention, there is provided a method for manufacturing a spunbond nonwoven fabric, the method including the steps of:

melt-spinning a thermoplastic resin to obtain a continuous filament bundle;
allowing the continuous filament bundle to collide with a metal member containing bismuth (Bi) or a bismuth alloy to obtain filaments opened by frictional charging; and
converging the opened filaments on a continuous conveyor net to form a fiber web.

[0025] Conventionally, the opening process according to the Docan system was controlled by the generation of electrostatic force by friction between the filament bundle and the lead plate material, and the lead plate material is worn by the kinetic energy of the filament, and a trace amount of lead remains in the manufactured nonwoven fabric.

[0026] However, unlike industrial materials, there is a risk that residual lead may be exposed through the oral cavity, respiratory system, or skin in household chemical materials, and these potential risks made it difficult to enter the market.

[0027] However, the present inventors have conducted intensive research, and as a result, found that when a metal member containing bismuth (Bi) or a bismuth alloy is applied as a friction material in the manufacture of a spunbond nonwoven fabric according to the Docan system, it can exhibit a negative charge donation ability in the same level as that of the metal member, which is a conventional lead (Pb) material, and it can also manufacture a spunbond nonwoven fabric with improved opening quality and with no hazardous residue.

[0028] FIG. 1 schematically shows an apparatus for manufacturing a spunbond nonwoven fabric according to an embodiment of the present invention.

[0029] First, (i) a step of melt-spinning a thermoplastic resin to obtain a continuous filament bundle is performed.

[0030] As the thermoplastic resin, conventional resins in the technical field to which the present invention pertains can be used without particular limitation.

[0031] The thermoplastic resin having a melting point of 200 °C or more may be advantageous for securing mechanical properties of the filaments.

[0032] Preferably, the thermoplastic resin may be at least one resin selected from the group consisting of polyester, polyamide, polyolefin, and polyphenylene sulfide.

[0033] Specifically, the thermoplastic resin may be at least one resin selected from the group consisting of polyethylene terephthalate, polybutylene terephthalate, polycyclohexane terephthalate, polyethylene naphthalate, nylon, polyethylene, polypropylene, polybutylene, and polyphenylene sulfide.

[0034] The thermoplastic resin is melted in a continuous extruder having a screw and a heating body, and continuously discharged through a spinneret, thereby forming a continuous filament bundle.

[0035] The continuous filament bundle is discharged through a jet nozzle while being drawn by compressed air and an ejector in a cylindrical pipe of the nozzle unit 10.

[0036] The fineness (denier) and cross-sectional shape of the filaments constituting the continuous filament bundle are not particularly limited. As a non-limiting example, the filaments may have fineness of 1 to 10 denier and a circular or multilobal cross-section.

[0037] Subsequently, (ii) a step of allowing the continuous filament bundle to collide with a metal member containing bismuth (Bi) or a bismuth alloy to obtain filaments opened by frictional charging is performed.

[0038] The step (ii) is a step in which the continuous filament bundle 11 discharged through the jet nozzle of the nozzle unit 10 is allowed to collide with the collision surface of the collision unit 20, so that frictional charging is induced by the charging sequence of the material of the collision surface and the filament bundle, and the filaments are opened by a Coulomb repulsive-force between the filaments having the same electric charge.

[0039] One of the main factors that determine the dispersion shape and opening quality of the filament bundle 11 in the step (ii) is the type of material forming the collision surface of the collision unit 20.

[0040] Lead (Pb) has been traditionally used as a material forming the collision surface of the collision unit 20. However, a trace amount of lead, which has fallen off due to friction with the filaments, remains in the nonwoven fabric, causing a potential risk that is hazardous to human bodies.

[0041] According to an approach based on solid-state physics, lead (Pb) is classified as follows. Lead (Pb) has conductivity of 5×10^6 S/m, and is electrically classified as a 'conductor' among conductors, semiconductors, and insulators. Lead (Pb) has a magnetic susceptibility of -23.0×10^{-6} cm³/mol (at 298 K), and is magnetically classified as "semimagnetic" among ferromagnetic, paramagnetic, and semimagnetic. Lead (Pb) has a melting point of 600.61 K (327.46°C, 621.43°F), and is thermally classified as a "low temperature melt" among high temperature melt and low temperature melt. Further, lead (Pb) has Vickers hardness (Hv) of 8.11, and is mechanically classified as 'soft' among hard and soft, and 'toughness' among brittleness and toughness.

[0042] According to one embodiment of the invention, the continuous filament bundle 11 is allowed to collide with a metal member containing bismuth (Bi) or a bismuth alloy.

[0043] Bismuth (Bi) has conductivity of 7.7×10^5 S/m and is electrically classified as a 'conductor'; has a magnetic susceptibility (at 298 K) of -280.1×10^{-6} cm³/mol, and is magnetically classified as 'semimagnetic'; has a melting point of 544.7 K (271.5 °C, 520.7 °F) and is thermally classified as a 'low temperature melt'; has a Vickers hardness (Hv) of 11.55 and is mechanically classified as 'soft' and 'tough'.

[0044] Bismuth (Bi) can exhibit an equivalent level of negative charge donation ability compared to lead (Pb), and is also harder and does not belong to hazardous substances according to the European Union's (EU) Restriction of Hazardous Substances Directive (RoHS).

[0045] Therefore, bismuth or a bismuth alloy is applied to the collision surface of the collision unit 20, thereby being capable of obtaining a spunbond nonwoven fabric which does not contain hazardous residue and has improved opening quality.

[0046] Preferably, a metal member made of bismuth can be applied to the collision surface of the collision unit 20.

[0047] Further, a metal member made of a bismuth alloy can be applied to the collision surface. Preferably, the bismuth

alloy contains 10 % by weight or more, or 20 % by weight or more, or 30 % by weight or more, or 40 % by weight or more, or 45 % by weight or more, or 50 % by weight or more of bismuth based on the weight of the bismuth alloy, which may be advantageous for exhibiting the above effects according to the present invention. Specifically, the bismuth alloy may contain 10 % to 80 % by weight, or 20 % to 80 % by weight, or 20 % to 70 % by weight, or 30 % to 70 % by weight, or 30 % to 60 % by weight, or 40 % to 60 % by weight, or 45 % to 60 % by weight, or 45 % to 55 % by weight of bismuth based on the weight of the bismuth alloy.

[0048] The bismuth alloy may, in addition to bismuth, further include a metal that does not impair the properties of bismuth while not belonging to hazardous substances according to the RoHS directive. For example, the bismuth alloy may include at least one metal selected from the group consisting of copper (Cu), zinc (Zn), tin (Sn), aluminum (Al), molybdenum (Mo), and titanium (Ti). As a non-limiting example, the bismuth alloy may contain 50 % by weight of bismuth (Bi) and 50 % by weight of copper (Cu). The metal other than bismuth contained in the bismuth alloy may be selected in consideration of physical properties possessed by the metal, physical properties to be imparted to the collision surface, and the like.

[0049] According to one embodiment of the invention, the continuous filament bundle 11 may collide with the metal member at a linear velocity of 4000 m/min to 6000 m/min, or 4500 m/min to 6000 m/min, or 4500 m/min to 5500 m/min.

[0050] Further, the continuous filament bundle 11 may collide with the metal member at a mass flow rate of 2.0 kg/h to 8.0 kg/h, or 3.0 kg/h to 8.0 kg/h, or 3.0 kg/h to 6.0 kg/h per nozzle that jets the continuous filament bundle 11.

[0051] In order to secure the opening quality and operation capacity while sufficiently generating frictional charging due to collision with the metal member, the continuous filament bundle 11 preferably collides with the metal member within the linear velocity range and the mass flow rate range.

[0052] According to one embodiment of the invention, the filaments 22 opened by the frictional charging may have a charge generation amount (value measured by the Faraday cage method) of -3500 nC/sec to -500 nC/sec, or -3400 nC/sec to -600 nC/sec, or -3400 nC/sec to -700 nC/sec.

[0053] The filaments 22 opened by the frictional charging have the charge generation amount within the above range, and thus can be opened with a wide opening width and excellent quality.

[0054] The charge generation amount possessed by the opened filaments 22 is an amount of electrostatic discharge that the filament has due to collision with the metal member, and can be measured using a Faraday cage method.

[0055] Faraday cages are divided into an inner cage and an outer cage. The insulated inner cage and is installed so that it collides with the metal member and the opened filaments 22 are confined. The grounded outer cage is installed so as to surround the entire surface of the inner cage. A digital coulomb meter is brought into contact with the inner cage. A time for which the difference in the amount of charge between the inner cage and the outer cage reaches -9000 nC is measured with a digital coulomb meter and normalized by the time, thereby obtaining the amount of electrostatic discharge possessed by the opened filaments.

[0056] According to one embodiment of the invention, the jet nozzle for jetting the filament bundle in the step (ii) is connected to a step motor shaft, and can be controlled at the nozzle rotation angle ranging from $-15 \pm 5^\circ$ to $+15 \pm 5^\circ$ and a nozzle reciprocating speed of 3 counters/sec to 12 counters/sec.

[0057] Subsequently, (iii) a step of converging the opened filaments 22 on a continuous conveyor net 30 to form a fiber web 33 is performed.

[0058] The filaments having a negative charge due to the frictional charging are opened by the Coulomb repulsive-force between the filaments, and fall downward where the continuous conveyor net 30 made of metal is located. Negatively charged filaments are seated on the grounded conveyor net 30 by electrostatic force to form a fiber web 33.

[0059] According to one embodiment of the invention, the opened filaments 22 are converged on the continuous conveyor net 30 with an opening width of 500 mm or more under conditions where the rotation angle range of the nozzle for jetting the filament bundle is $-15 \pm 5^\circ$ to $+15 \pm 5^\circ$ and the reciprocating speed of the nozzle is 3 counters/sec to 12 counters/sec.

[0060] In order to secure excellent opening quality, the opening width of the opened filaments 22 is preferably 500 mm or more. Preferably, the opening width may be 500 mm or more, or 500 mm to 700 mm, or 500 mm to 650 mm, or 520 mm to 650 mm.

[0061] Herein, the opening width means the maximum width based on the moving direction of the opened filaments 22 converged on the continuous conveyor net 30. The opening width is based on a value indicated by opened filaments obtained from one nozzle unit and a corresponding collision unit.

[0062] Then, the spunbond nonwoven fabric may be obtained by bonding the fibrous web by thermal bonding or the like. The bonding may be performed using a calender roll or an emboss roll.

II. Apparatus for manufacturing spunbond nonwoven fabric

[0063] According to another embodiment of the invention, there is provided an apparatus for manufacturing a spunbond nonwoven fabric, the apparatus including:

a plurality of nozzle units 10 configured and arranged so as to discharge a continuous filament bundle 11;
 a collision unit 20 that is adjacent to each of the nozzle units 10 at a position for colliding with the continuous filament bundle 11 jetted by the nozzle units 10; and
 a continuous conveyor net 30 that collects and conveys filaments 22 opened by frictional charging with the collision unit,
 wherein the collision unit 20 includes a collision surface that is a metal member containing bismuth (Bi) or a bismuth alloy.

[0064] The apparatus for manufacturing a spunbond nonwoven fabric can be used for carrying out the above-mentioned
 『I. Method for manufacturing spunbond nonwoven fabric.』.

[0065] FIG. 1 schematically shows an apparatus for manufacturing a spunbond nonwoven fabric according to one embodiment of the present invention.

[0066] The apparatus for manufacturing a spunbond nonwoven fabric according to an embodiment of the invention includes a plurality of nozzle units 10 configured and arranged so as to discharge a continuous filament bundle 11.

[0067] A thermoplastic resin, which is a raw material, is melted in a continuous extruder (not shown in FIG. 1) having a screw and a heating body, and continuously discharged through a spinneret to form a continuous filament bundle.

[0068] The nozzle unit 10 includes a cylindrical pipe connected to the spinneret and a jet nozzle formed on one side of the cylindrical pipe.

[0069] The continuous filament bundle is drawn by compressed air and an ejector in the cylindrical pipe of the nozzle unit 10 and discharged through a jet nozzle.

[0070] The jet nozzle is connected to a step motor shaft and controlled at a nozzle rotation angle ranging from $-15 \pm 5^\circ$ to $+15 \pm 5^\circ$ and a nozzle reciprocating speed of 3 counters/sec to 12 counters/sec.

[0071] The jet nozzle can discharge the continuous filament bundle 11 at a linear speed of 4000 m/min to 6000 m/min, or 4500 m/min to 6000 m/min, or 4500 m/min to 5500 m/min.

[0072] And, the continuous filament bundle 11 may collide with the metal member of the collision unit 20 at a mass flow rate of 2.0 kg/h to 8.0 kg/h, or 3.0 kg/h to 8.0 kg/h, or 3.0 kg/h to 6.0 kg/h per nozzle that jets the continuous filament bundle.

[0073] The apparatus for manufacturing a spunbond nonwoven fabric according to an embodiment of the invention includes a collision unit 20 that is adjacent to each of the nozzle units 10 at a position for colliding with the continuous filament bundle 11 jetted by the nozzle units 10.

[0074] The collision unit 20 includes a collision surface that is a metal member containing bismuth (Bi) or a bismuth alloy. The collision surface means a surface that directly collides with the continuous filament bundle 11 in the collision unit 20.

[0075] Preferably, a metal member made of bismuth can be applied to the collision surface of the collision unit 20.

[0076] Further, a metal member made of a bismuth alloy can be applied to the collision surface. Preferably, the bismuth alloy may contain 10 % by weight or more, or 20 % by weight or more, or 30 % by weight or more, or 40 % by weight or more, or 45 % by weight or more, or 50 % by weight or more of bismuth based on the weight of the bismuth alloy, which may be advantageous for exhibiting the above effects according to the present invention. Specifically, the bismuth alloy may contain 10 % to 80 % by weight, or 20 % to 80 % by weight, or 20 % to 70 % by weight, or 30 % to 70 % by weight, or 30 % to 60 % by weight, or 40 % to 60 % by weight, or 45 % to 60 % by weight, or 45 % to 55 % by weight of bismuth based on the weight of the bismuth alloy.

[0077] The bismuth alloy may, in addition to bismuth, further include a metal that does not impair the properties of bismuth while not belonging to hazardous substances according to the RoHS directive. For example, the bismuth alloy may include at least one metal selected from the group consisting of copper (Cu), zinc (Zn), tin (Sn), aluminum (Al), molybdenum (Mo), and titanium (Ti). As a non-limiting example, the bismuth alloy may contain 50 % by weight of bismuth (Bi) and 50 % by weight of copper (Cu). The metal other than bismuth contained in the bismuth alloy may be selected in consideration of physical properties possessed by the metal, physical properties to be imparted to the collision surface, and the like.

[0078] The collision unit 20 may be installed at a predetermined angle that allows the filaments 22 opened by frictional charging to be collected on the continuous conveyor net 30 at a position for colliding with the continuous filament bundle 11 discharged by the nozzle units 10.

[0079] The apparatus for manufacturing a spunbond nonwoven fabric according to an embodiment of the present invention includes a continuous conveyor net 30 that collects and conveys filaments 22 opened by frictional charging with the collision unit 20.

[0080] The continuous conveyor net 30 is preferably grounded. That is, it is preferable to configure such that the opened filament 22 that has become negatively charged due to riboelectric charging with the collision unit 20 can be seated on the continuous conveyor net 30 by electrostatic force.

[0081] The continuous conveyor net 30 continuously conveys the fiber web 33 formed by collecting the opened filaments 22.

[0082] In addition, the apparatus for manufacturing a spunbond nonwoven fabric according to an embodiment of the present invention may include a bonding unit that adjusts and bonds the fiber web 33 to a predetermined thickness.

[0083] The bonding unit can have conventional configurations such as calender rolls and embossing rolls used for bonding nonwoven fabrics in the technical field to which this invention belongs.

III. Spunbond nonwoven fabric

[0084] According to another embodiment of the invention, there is provided a spunbond nonwoven fabric which is obtained by the above-mentioned manufacturing method, includes a fiber web containing thermoplastic resin filaments, and has a residual amount of bismuth (Bi) of 0.01 ppmw to 10.0 ppmw.

[0085] The spunbond nonwoven fabric can be obtained according to the above-mentioned "I. Method for manufacturing spunbond nonwoven fabric".

[0086] Further, the spunbond nonwoven fabric can be obtained by using "II. Apparatus for manufacturing spunbond nonwoven fabric".

[0087] According to an embodiment of the invention, the spunbond nonwoven includes a fiber web including thermoplastic resin filaments.

[0088] The thermoplastic resin filament is obtained by using a thermoplastic resin.

[0089] As the thermoplastic resin, conventional resins in the technical field to which the present invention belongs can be used without particular limitation.

[0090] The thermoplastic resin having a melting point of 200 °C or more may be advantageous for securing mechanical properties of the filaments.

[0091] Preferably, the thermoplastic resin may be at least one resin selected from the group consisting of polyester, polyamide, polyolefin, and polyphenylene sulfide.

[0092] Specifically, the thermoplastic resin may be at least one resin selected from the group consisting of polyethylene terephthalate, polybutylene terephthalate, polycyclohexane terephthalate, polyethylene naphthalate, nylon, polyethylene, polypropylene, polybutylene, and polyphenylene sulfide.

[0093] The fineness (denier) and cross-sectional shape of the filaments is not particularly limited. As a non-limiting example, the filaments may have fineness of 1 to 10 denier and a circular or multilobal cross-section.

[0094] In order to secure excellent mechanical properties, the spunbond nonwoven fabric may have a weight per unit area of 20 to 150 g/m², or 50 to 120 g/m².

[0095] Particularly, as the spunbond nonwoven fabric is obtained according to the above-mentioned "I. Method for manufacturing spunbond nonwoven fabric", it is possible to exhibit improved opening quality without substantially containing hazardous residues such as lead (Pb).

[0096] According to one embodiment of the invention, the spunbond nonwoven fabric may have a residual amount of lead (Pb) of 0.1 ppmw or less. Preferably, the spunbond nonwoven does not contain residual lead.

[0097] According to one embodiment of the invention, the spunbond nonwoven fabric includes a filament opened by collision with a metal member containing bismuth (Bi) or a bismuth alloy, and may have a residual amount of bismuth (Bi) of 0.01 ppmw to 10.0 ppmw, or 0.05 ppmw to 5.0 ppmw, or 0.1 ppmw to 2.5 ppmw.

[0098] In addition, the residual amount of metals other than bismuth contained in the bismuth alloy in the spunbond nonwoven fabric may be 0.1 ppmw or less. The bismuth alloy may include at least one metal selected from the group consisting of copper (Cu), zinc (Zn), tin (Sn), aluminum (Al), molybdenum (Mo), and titanium (Ti).

[0099] According to one embodiment of the invention, the spunbond nonwoven fabric may have a quality index (Q) of 350 or less, which is defined by the following Equation 1:

[Equation 1]

$$\text{Quality Index (Q)} = \text{SD} / \text{OD}$$

wherein in the above Equation 1,

OD is the optical density of the spunbond nonwoven fabric measured using a formation tester, and SD is the standard deviation of OD (optical density).

[0100] The optical density (OD) is a value obtained through the transmittance of a light source per unit area of the spunbond nonwoven fabric and the distribution of the transmittance. The quality index (Q) is a value obtained by normalizing the standard deviation (SD) of the optical density by the optical density (OD). The OD and SD may be obtained using conventional formation testers used in the technical field to which the present invention belongs.

[0101] In order to ensure uniform and excellent quality, the spunbond nonwoven fabric preferably has a quality index (Q) of 350 or less. More preferably, the quality index (Q) of the spunbond nonwoven fabric may be 250 to 350, or 270 to 350, or 275 to 300.

[Advantageous Effects]

[0102] According to the present invention, a method and an apparatus for manufacturing a spunbond nonwoven fabric having improved opening quality by using a friction material that is not harmful to the human body while having a negative charge donation ability in the same level as that of lead (Pb) is provided. In the apparatus, it is possible to extend the replacement period of the friction material and also contribute to the improvement of operation capacity. The spunbond nonwoven fabric manufactured according to the above apparatus and method does not contain hazardous residues and has improved opening quality, and thus is applied not only as an industrial material but also as a household chemical material, eliminating a potential risk that is hazardous to human bodies.

[BRIEF DESCRIPTION OF THE DRAWING]

[0103] FIG. 1 schematically shows an apparatus for manufacturing a spunbond nonwoven fabric according to one embodiment of the present invention.

[Description of Reference Numerals]

10:	nozzle unit	11:	filament bundle
20:	collision unit	22:	opened filaments
30:	conveyor net	33:	fiber web

[DETAILED DESCRIPTION OF THE EMBODIMENTS]

[0104] Hereinafter, preferred examples are provided for better understanding. However, these examples are for illustrative purposes only, and the invention is not intended to be limited by these examples.

Example 1

[0105] A spunbond nonwoven fabric was manufactured using the apparatus according to FIG. 1.

[0106] First, polyethylene terephthalate resin having an intrinsic viscosity (IV) of 0.665 dl/g and a melting point (T_m) of 254 °C was allowed to melt at 284 °C, and discharged continuously. The filament bundle obtained by the discharge was discharged through an EDJ (electric distribution jet) nozzle, while being drawn at a speed of 5000 m/min using compressed air and an ejector in the cylindrical pipe of the nozzle unit. The EDJ nozzle was connected to a step motor shaft, and controlled at a nozzle rotation angle ranging from - 15±5° to +15±5° and a nozzle reciprocating speed of 10 counters/sec.

[0107] The discharged filament bundle collided at the above speed with the collision unit located at a predetermined angle adjacent to the nozzle unit. A metal member (a metal plate having a thickness of 2.0±0.15 mm) made of bismuth (Bi) was used as the collision surface of the collision unit. At this time, the mass flow rate of the filament colliding with the metal member was 5.0 kg/h per nozzle for jetting the continuous filament bundle, and the linear velocity of the filament was controlled at 5000 m/min.

[0108] The filaments, which have become negatively charged due to frictional charging with the collision unit, fall downward where the conveyor net was located while being opened by the Coulomb repulsive-force between filaments. Negatively charged filaments were seated by electrostatic force on the grounded continuous conveyor net to form a fiber web.

[0109] The fiber web was passed between calender rollers maintained at 130 °C and 35 N/mm to have an appropriate thickness. Then, hot air was applied to the fiber web and was thermally bonded to obtain a spunbond nonwoven fabric (thickness: 0.27±0.03 mm, weight: 60±2.0 g/m²).

Example 2

[0110] A spunbond nonwoven fabric was obtained in the same manner as in Example 1, except that a metal member made of a bismuth/copper alloy (50 wt.% of Bi, 50 wt.% of Cu) was applied to the collision surface of the collision unit instead of a bismuth metal member.

Comparative Example 1

[0111] A spunbond nonwoven fabric was obtained in the same manner as in Example 1, except that a metal member made of lead (Pb) was applied to the collision surface of the collision unit instead of a bismuth metal member.

Comparative Example 2

[0112] A spunbond nonwoven fabric was obtained in the same manner as in Example 1, except that a metal member made of copper (Cu) was applied to the collision surface of the collision unit instead of a bismuth metal member.

Comparative Example 3

[0113] A spunbond nonwoven fabric was obtained in the same manner as in Example 1, except that a metal member made of tin (Sn) was applied to the collision surface of the collision unit instead of a bismuth metal member.

Comparative Example 4

[0114] A spunbond nonwoven fabric was obtained in the same manner as in Example 1, except that a metal member made of aluminum (Al) was applied to the collision surface of the collision unit instead of a bismuth metal member.

Comparative Example 5

[0115] A spunbond nonwoven fabric was obtained in the same manner as in Example 1, except that a metal member made of zinc (Zn) was applied to the collision surface of the collision unit instead of a bismuth metal member.

Comparative Example 6

[0116] A spunbond nonwoven fabric was obtained in the same manner as in Example 1, except that a metal member made of molybdenum (Mo) was applied to the collision surface of the collision unit instead of a bismuth metal member.

Comparative Example 7

[0117] A spunbond nonwoven fabric was obtained in the same manner as in Example 1, except that a metal member made of titanium (Ti) was applied to the collision surface of the collision unit instead of a bismuth metal member.

Test Example

(1) Charge generation amount (nC/s)

[0118] Using the Faraday cage method, the amount of electrostatic discharge per unit time of the opened filaments was measured.

[0119] Faraday cages are divided into an inner cage and an outer cage. The insulated inner cage was installed so that the filaments 22 opened by colliding with the metal member is confined. The grounded outer cage was installed so as to surround the entire surface of the inner cage. A digital coulomb meter (NK-1002, KASUGA DENKI, Inc.) was brought into contact with the inner cage. A time for which the difference in the amount of charge between the inner cage and the outer cage reached -9000 nC was measured with the digital coulomb meter and normalized by time, thereby obtaining the amount of electrostatic discharge possessed by the opened filaments.

(2) Opening width (mm)

[0120] The opening width formed by the filaments opened by frictional charging with the collision unit was measured. Herein, the opening width means the maximum width based on the moving direction of the opened filaments converged

on the continuous conveyor net. The opening width was based on a value indicated by opened filaments obtained from one nozzle unit and a corresponding collision unit. The opening width was expressed as an average value after 10 measurements under the conditions where the rotation angle range of the EDJ nozzle was $-15\pm 5^\circ$ to $+15\pm 5^\circ$ and the reciprocating speed of the EDJ nozzle was 10 counters/s.

(3) Quality Index (Q)

[0121] Using a formation tester (FMT-III, Manufactured by NOMURA SHOJI CO.), the optical density (OD) and the standard deviation of the optical density were measured through the transmittance of the light from the light source per unit area of the spunbond nonwoven fabric and the distribution of the transmittance (SD). The quality index was calculated according to the following Equation 1.

[0122] The formation tester (FMT-III) is an image analysis type quality analyzer using a two-dimensional CCD camera. The nonwoven sample was placed on a stage illuminated from below. The CCD camera captured an image of 320x230 pixels, and the light intensity was measured by each pixel. A PC connected to a CCD camera converted the light intensity into transmittance (%) and optical density (OD).

(4) Use period of metal members (days)

[0123] In the manufacturing process of the spunbond nonwoven fabric, the time point at which perforation in the thickness direction occurs in the metal member (metal plate having a thickness of 2.0 ± 0.15 mm) contained in the collision unit or the time point at which operability deteriorates by the occurrence of unevenness due to wear was measured. At this time, the mass flow rate of the filament colliding with the metal member was 5.0 kg/h per nozzle for jetting the continuous filament bundle, and the linear velocity of the filaments was controlled in the range of 5000 m/min.

(5) Amount of inorganic residue (ppmw)

[0124] The amount of inorganic residues in the spunbond nonwoven fabric was measured using inductively coupled plasma (ICP). Specimens of spunbond nonwoven fabrics were pretreated with an aqueous solution from which particles and organic material were removed by acid decomposition. The amount of inorganic residues in the specimen was primarily measured using inductively coupled plasma-atomic emission spectroscopy (ICP-AES). When inorganic residues were not detected, re-measurement was performed by increasing the resolution using inductively coupled plasma-mass spectroscopy (ICP-MS).

[Table 1]

	Material of metal member	Charge generation amount (nC/s)	Opening width (mm)	Quality index (Q)	Use period (days)	Amount of inorganic residue (ppmw)	Availability
Example 1	Bi	-3350	610	278	7.3	1.13	◎
Example 2	Bi-Cu	-1828	530	297	16.5	Bi 0.17, Cu 0.09	○
Comparative Example 1	Pb	-2543	540	284	3.8	7.51	Heavy metal detected
Comparative Example 2	Cu	-925	330	432	41.2	0.57	Defective quality
Comparative Example 3	Sn	+163	210	603	15.5	0.14	Defective opening
Comparative Example 4	Al	+179	370	594	-	Not detected	Defective opening
Comparative Example 5	Zn	+275	350	681	-	Not detected	Defective opening
Comparative Example 6	Mo	+1,440	390	725	-	Not detected	Defective opening

(continued)

	Material of metal member	Charge generation amount (nC/s)	Opening width (mm)	Quality index (Q)	Use period (days)	Amount of inorganic residue (ppmw)	Availability
Comparative Example 7	Ti	+132	330	656	-	Not detected	Defective opening

[0125] Referring to Table 1, Comparative Example 1 was excellent in quality index and opening width, but residual lead was detected in the nonwoven fabric, making it unsuitable for use as a household chemical material.

[0126] Examples had the quality index and opening width in the same level as those of Comparative Example 1, but no hazardous residues were detected in the nonwoven fabric. Further, it was confirmed that the metal member applied to the examples had a use period of about twice or more compared to Comparative Example 1, and thus the operation capacity was significantly improved.

[0127] It was confirmed that in Comparative Examples 2 and 3, the amount of inorganic residues of the nonwoven fabric was low, but the quality index and opening width were inferior, and that in Comparative Examples 4 to 7, no inorganic residues were detected in the nonwoven fabric, but the opening of the filaments was defective.

Claims

1. A method for manufacturing a spunbond nonwoven fabric, the method comprising the steps of:

melt-spinning a thermoplastic resin to obtain a continuous filament bundle;
allowing the continuous filament bundle to collide with a metal member containing bismuth (Bi) or a bismuth alloy to obtain filaments opened by frictional charging; and
converging the opened filaments on a continuous conveyor net to form a fiber web.

2. The method for manufacturing a spunbond nonwoven fabric according to claim 1, wherein the bismuth alloy contains 10 % by weight or more of bismuth based on the weight of the bismuth alloy.

3. The method for manufacturing a spunbond nonwoven fabric according to claim 1, wherein the bismuth alloy comprises at least one metal selected from the group consisting of copper (Cu), zinc (Zn), tin (Sn), aluminum (Al), molybdenum (Mo), and titanium (Ti).

4. The method for manufacturing a spunbond nonwoven fabric according to claim 1, wherein the continuous filament bundle collides with the metal member at a linear velocity of 4000 m/min to 6000 m/min and a mass flow rate of 2.0 kg/h to 8.0 kg/h per nozzle that jets the continuous filament bundle.

5. The method for manufacturing a spunbond nonwoven fabric according to claim 1, wherein the opened filaments have a charge generation amount by the frictional charging (a value measured by a Faraday cage method) of -3500 nC/s to -500 nC/s.

6. The method for manufacturing a spunbond nonwoven fabric according to claim 1, wherein the opened filaments are converged on the continuous conveyor net with an opening width of 500 mm or more under conditions where the rotation angle range of the nozzle for jetting the filament bundle is $-15 \pm 5^\circ$ to $+15 \pm 5^\circ$ and the reciprocating speed of the nozzle is 3 counters/s to 12 counters/s (wherein the opening width means the maximum width based on the moving direction of the opened filaments converged on the continuous conveyor net).

7. The method for manufacturing a spunbond nonwoven fabric according to claim 1, wherein the thermoplastic resin has a melting point of 200 °C or more, and the thermoplastic resin is at least one resin selected from the group consisting of polyester, polyamide, polyolefin, and polyphenylene sulfide.

8. The method for manufacturing a spunbond nonwoven fabric according to claim 1, wherein the thermoplastic resin is at least one resin selected from the group consisting of polyethylene terephthalate, polybutylene terephthalate, polycyclohexane terephthalate, polyethylene naphthalate, nylon, polyethylene, polypropylene, polybutylene, and polyphenylene sulfide.

9. An apparatus for manufacturing a spunbond nonwoven fabric, the apparatus comprising:

a plurality of nozzle units configured and arranged so as to discharge a continuous filament bundle;
a collision unit that is adjacent to each of the nozzle units at a position for colliding with the continuous filament
bundle jetted by the nozzle units; and
a continuous conveyor net that collects and conveys filaments opened by frictional charging with the collision unit,
wherein the collision unit comprises a collision surface that is a metal member containing bismuth (Bi) or a
bismuth alloy.

10. The apparatus for manufacturing a spunbond nonwoven fabric according to claim 9, wherein the bismuth alloy contains 10 % by weight or more of bismuth based on the weight of the bismuth alloy.

11. The apparatus for manufacturing a spunbond nonwoven fabric according to claim 9, wherein the bismuth alloy comprises at least one metal selected from the group consisting of copper (Cu), zinc (Zn), tin (Sn), aluminum (Al), molybdenum (Mo), and titanium (Ti).

12. The apparatus for manufacturing a spunbond nonwoven fabric according to claim 9, wherein the nozzle unit comprises a jet nozzle that discharges the continuous filament bundle, and the jet nozzle is connected to a step motor shaft and is controlled at a nozzle rotation angle ranging from $-15 \pm 5^\circ$ to $+15 \pm 5^\circ$ and a nozzle reciprocating speed of 3 counters/s to 12 counters/s.

13. A spunbond nonwoven fabric which is obtained by the method according to claim 1, comprises a fiber web containing thermoplastic resin filaments, and has a residual amount of bismuth (Bi) of 0.01 ppmw to 10.0 ppmw.

14. The spunbond nonwoven fabric according to claim 13, wherein the spunbond nonwoven fabric has a residual amount of lead (Pb) of 0.1 ppmw or less.

15. The spunbond nonwoven fabric according to claim 13, wherein the spunbond nonwoven fabric has a quality index (Q) of 350 or less, which is defined by the following Equation 1:

[Equation 1]

$$\text{Quality index (Q)} = \text{SD} / \text{OD}$$

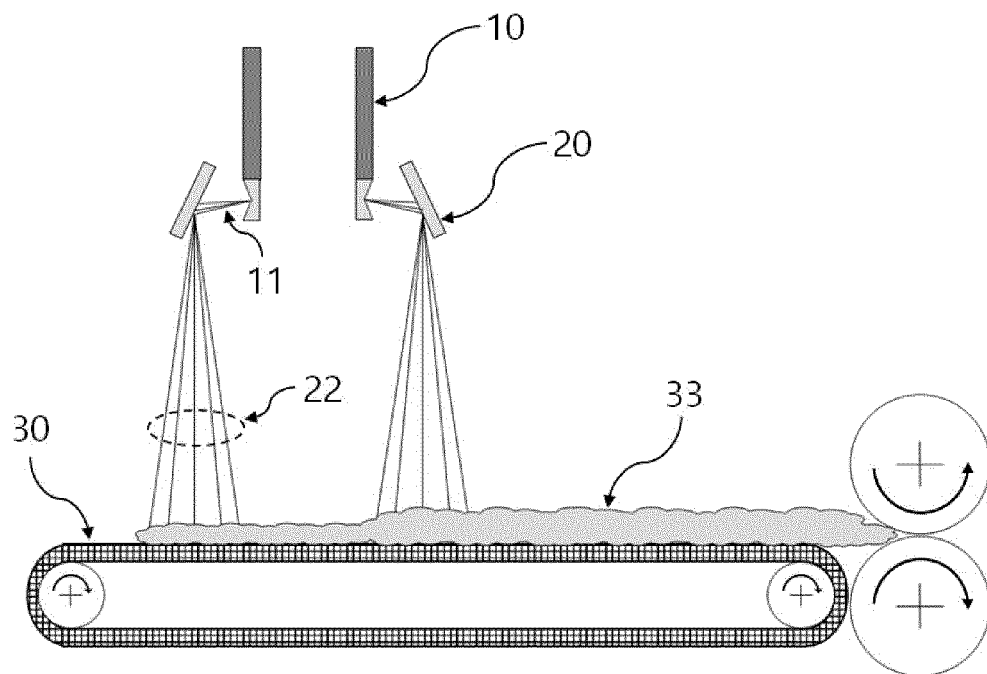
and in the above Equation 1,

OD is the optical density of the spunbond nonwoven fabric measured using a formation tester, and
SD is the standard deviation of OD (optical density).

16. The spunbond nonwoven fabric according to claim 13, wherein the thermoplastic resin has a melting point of 200 °C or more, and the thermoplastic resin is at least one resin selected from the group consisting of polyester, polyamide, polyolefin, and polyphenylene sulfide.

17. The spunbond nonwoven fabric according to claim 13 wherein the thermoplastic resin is at least one resin selected from the group consisting of polyethylene terephthalate, polybutylene terephthalate, polycyclohexane terephthalate, polyethylene naphthalate, nylon, polyethylene, polypropylene, polybutylene, and polyphenylene sulfide.

【FIG. 1】



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2021/010410

A. CLASSIFICATION OF SUBJECT MATTER D04H 3/147(2012.01)i; D04H 3/011(2012.01)i; D04H 3/007(2012.01)i According to International Patent Classification (IPC) or to both national classification and IPC																		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) D04H 3/147(2012.01); D01D 5/098(2006.01); D02J 1/18(2006.01); D04H 3/011(2012.01); D04H 3/16(2006.01); H01T 19/00(2006.01) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models: IPC as above Japanese utility models and applications for utility models: IPC as above Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS (KIPO internal) & keywords: 부직포 (nonwoven), 스펀본드 (spunbond), 비스무트 (bismuth), 개설펀 (opening)																		
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>JP 05-093353 A (TORAY IND. INC.) 16 April 1993 (1993-04-16) See claim 1; paragraphs [0016] and [0023]-[0025]; and figure 1.</td> <td>1-17</td> </tr> <tr> <td>A</td> <td>JP 08-158232 A (TORAY IND. INC.) 18 June 1996 (1996-06-18) See claim 1; and paragraphs [0033]-[0035].</td> <td>1-17</td> </tr> <tr> <td>A</td> <td>KR 10-1441593 B1 (TORAY INDUSTRIES, INC.) 19 September 2014 (2014-09-19) See entire document.</td> <td>1-17</td> </tr> <tr> <td>A</td> <td>JP 2008-159374 A (KASUGA ELECTRIC WORKS LTD. et al.) 10 July 2008 (2008-07-10) See entire document.</td> <td>1-17</td> </tr> <tr> <td>A</td> <td>KR 10-2019-0066019 A (TORAY INDUSTRIES, INC.) 12 June 2019 (2019-06-12) See entire document.</td> <td>1-17</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	JP 05-093353 A (TORAY IND. INC.) 16 April 1993 (1993-04-16) See claim 1; paragraphs [0016] and [0023]-[0025]; and figure 1.	1-17	A	JP 08-158232 A (TORAY IND. INC.) 18 June 1996 (1996-06-18) See claim 1; and paragraphs [0033]-[0035].	1-17	A	KR 10-1441593 B1 (TORAY INDUSTRIES, INC.) 19 September 2014 (2014-09-19) See entire document.	1-17	A	JP 2008-159374 A (KASUGA ELECTRIC WORKS LTD. et al.) 10 July 2008 (2008-07-10) See entire document.	1-17	A	KR 10-2019-0066019 A (TORAY INDUSTRIES, INC.) 12 June 2019 (2019-06-12) See entire document.	1-17
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<table border="1"> <tr> <td>Date of the actual completion of the international search 23 November 2021</td> <td>Date of mailing of the international search report 23 November 2021</td> </tr> </table>	Date of the actual completion of the international search 23 November 2021	Date of mailing of the international search report 23 November 2021																
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<table border="1"> <tr> <td> Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon Building 4, 189 Cheongsaro, Seo-gu, Daejeon 35208 Facsimile No. +82-42-481-8578 </td> <td> Authorized officer Telephone No. </td> </tr> </table>	Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon Building 4, 189 Cheongsaro, Seo-gu, Daejeon 35208 Facsimile No. +82-42-481-8578	Authorized officer Telephone No.																
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2021/010410

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