US 20250137179A1

(19) **United States**
(12) **Patent Application Publication**
(10) **Pub. No.: US 2025/0137179 A1**
(43) **Pub. Date: May 1, 2025**
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(54) **NON-WOVEN FABRIC, PRODUCTION METHOD FOR SAME, AND BUILDING MATERIAL**

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(21) Appl. No.: **18/835,247**

(22) PCT Filed: **Jan. 30, 2023**

(86) PCT No.: **PCT/JP2023/002821**

§ 371 (c)(1),
(2) Date: **Aug. 1, 2024**

(30) **Foreign Application Priority Data**

Feb. 4, 2022 (JP) 2022-016076

Publication Classification

(51) **Int. Cl.**
D04H 3/16 (2006.01)

(52) **U.S. Cl.**
CPC ***D04H 3/16*** (2013.01); *D10B 2401/10* (2013.01); *D10B 2505/20* (2013.01)

(57) **ABSTRACT**

The present disclosure provides a non-woven fabric having a smooth surface and an excellent adhesive force with respect to an adhesive tape, for example, a waterproof tape.

NON-WOVEN FABRIC, PRODUCTION METHOD FOR SAME, AND BUILDING MATERIAL

TECHNICAL FIELD

[0001] The present invention relates to a non-woven fabric having excellent workability.

BACKGROUND ART

[0002] A ventilation layer construction method has become widespread in the construction of wooden houses, and the like, in which a ventilation layer is provided between an outer wall material and a heat insulating material so that moisture entering the wall body can be released to the outside through the ventilation layer. For this ventilation layer, a house wrap material, which is a moisture-permeable waterproof sheet having both a waterproof property for preventing rainwater from entering from the outside of a building and moisture permeability for allowing moisture generated in a wall body to be released to the outside, is used. When the house wrap is used for construction, a waterproof tape such as a butyl tape having excellent durability and adhesiveness over a long period of time is used particularly for a portion requiring waterproofness, the waterproof tape is attached to the skeleton of the building, and then a house wrap material is attached onto the waterproof tape. For this reason, such house wrap materials are required to have adhesiveness with respect to waterproof tapes.

[0003] As such a house wrap material, for example, Patent Document 1 proposes a non-woven fabric for a house wrap material which is a long-fiber non-woven fabric composed of thermoplastic continuous filaments, in which the filament has a fiber orientation degree of 35 to 70 degrees in the longitudinal direction of the non-woven fabric, the filaments are pressure-bonded to each other on one surface of the non-woven fabric, a large number of partial thermocompression bonding portions which are intermittent in any direction are formed over the entire non-woven fabric, and in the partial thermocompression bonding portion, at least some of the filaments are bonded to each other and aggregated.

PRIOR ART DOCUMENT

Patent Document

[0004] Patent Document 1: Japanese Patent Laid-open Publication No. 2014-040677

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0005] However, since the non-woven fabric for a house wrap material disclosed in Patent Document 1 has the partial heat bonding portion, there is a problem that the adhesiveness with respect to waterproof tapes is insufficient, which may cause the non-woven fabric to peel off from the waterproof tape due to its weight. Therefore, the present invention has been made in view of the above circumstances, and aims to provide a non-woven fabric having an excellent adhesive force with respect to adhesive tapes, for example, waterproof tapes.

Solutions to the Problems

[0006] As a result of repeating intense discussion to achieve the goal, the present inventors have found that, by setting a thickness CV value that is a coefficient of variation of a thickness of a non-woven fabric and porosity seen from the surface, and a porosity seen from the surface CV value that is a coefficient of variation of the porosity seen from the surface to be in specific ranges, a non-woven fabric having a smooth surface and an excellent adhesive force with respect to adhesive tapes can be obtained.

[0007] The present invention has been completed based on the findings, and is configured as follows.

[0008] [1] A non-woven fabric comprising a fiber containing a thermoplastic resin as a principal component, wherein a thickness CV value is 1.0% or more and 10.0% or less, a porosity seen from the surface is 10% or more and 30% or less, and a porosity seen from the surface CV value is 10% or more and 30% or less.

[0009] [2] The non-woven fabric described in [1], in which the non-woven fabric is for a building material.

[0010] [3] The non-woven fabric described in [1] or [2], in which an apparent density of the non-woven fabric is 0.40 g/cm^3 or more and 0.70 g/cm^3 or less.

[0011] [4] The non-woven fabric described in any one of [1] to [3], in which a basis weight of the non-woven fabric is 20 g/m^2 or more and 60 g/m^2 or less.

[0012] [5] A production method for the non-woven fabric described in any one of [1] to [4], the production method including spinning a thermoplastic resin to form non-woven webs, then setting a temperature of the non-woven webs to 100° C. or more and 160° C. or less, and then bonding the non-woven webs such that a ratio A of an average single fiber diameter calculated in the following formula (1) is 0.85 or more and 0.95 or less.

$$A = (\text{Average single fiber diameter of non-woven webs before bonding } (\mu\text{m}))/(\text{Average single fiber diameter of non-woven fabric after bonding } (\mu\text{m})) \quad (1)$$

[0013] [6] A building material including the non-woven fabric described in any one of [1] to [4].

Effects of the Invention

[0014] According to the present invention, there is provided a non-woven fabric having a smooth surface and an excellent adhesive force with respect to an adhesive tape, for example, a waterproof tape.

Embodiments of the Invention

[0015] A non-woven fabric of the present invention is a non-woven fabric made from fibers containing a thermoplastic resin as a principal component, and has a thickness CV value of 1.0% or more to 10.0% or less, a porosity seen from the surface of 10% or more to 30% or less, and a porosity seen from the surface CV value of 10% or more and 30% or less. Hereinafter, although the constituent elements of the non-woven fabric will be described in detail, the present invention is not limited to the scope described below at all, as long as it does not exceed the gist thereof.

[Fiber Containing Thermoplastic Resin as Principal Component]

[0016] First, examples of a thermoplastic resin for the non-woven fabric of the present invention include polyesters, polyamides, polyolefins, and mixtures or copolymers thereof. Among them, polyesters are preferably used because they have excellent mechanical strength, and excellent durability such as heat resistance, water resistance, and chemical resistance.

[0017] A polyester is a high molecular polymer with an acid component and an alcohol component as monomers. In the present invention, as the acid component, aromatic carboxylic acids such as terephthalic acid (ortho-form), isophthalic acid, and terephthalic acid; aliphatic dicarboxylic acids such as adipic acid and sebacic acid; alicyclic dicarboxylic acids such as cyclohexanecarboxylic acid; and the like can be used. In addition, as the alcohol component, ethylene glycol, diethylene glycol, and the like can be used.

[0018] Specific examples of the polyester include polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polytrimethylene terephthalate (PTT), polyethylene naphthalate, polylactic acid, and polybutylene succinate. In addition, as the polyester to be used as the high-melting polymer described later, polyethylene terephthalate (PET), which has a higher melting point, is excellent in heat resistance and also excellent in rigidity and is most preferably used.

[0019] To these polyester raw materials, additives such as a nucleating agent, a matting agent, a lubricant, a pigment, an antifungal agent, an antibacterial agent, a flame retardant, a metal oxide, an aliphatic bisamide and/or an alkyl-substituted aliphatic monoamide, and a hydrophilic agent can be added as long as the effect of the present invention is not impaired. Among them, a metal oxide such as titanium oxide exhibits effects of improving the spinnability by reducing the surface friction of the fibers and preventing bonding between the fibers, and improving the bonding property of the long-fiber non-woven fabric by increasing the thermal conductivity at the time of bonding molding of the long-fiber non-woven fabric with a heat roll. In addition, aliphatic bisamides such as ethylene-bis-stearic acid amide, and/or alkyl-substituted aliphatic monoamides, have effects of enhancing the property of mold-releasing between a heat roll and a non-woven fabric web and improving the conveying performance.

[0020] The non-woven fabric of the present invention is made of a fiber containing the thermoplastic resin as a principal component. The “principal component” mentioned herein is a component that accounts for 50 mass % or more among the components of the fiber.

[0021] The fiber according to the present invention is preferably a composite fiber in which a low-melting-point polymer having a melting point lower than that of a high-melting-point polymer is disposed around the high-melting-point polymer. By forming a composite fiber in such a form, fibers are easily firmly bonded in the non-woven fabric, and as a result, fluffing of the surface of the non-woven fabric is curbed, and a smooth surface can be easily obtained. Furthermore, for example, when the non-woven fabric is used as a house wrap material, the fibers constituting the non-woven fabric are firmly fused to each other, and the number of fusion points between the fibers in the non-woven fabric can also be increased as compared with a case where fibers having different melting points are mixed, so that the mechanical strength can also be improved.

[0022] The difference between the melting point of the high-melting-point polymer and the melting point of the low-melting-point polymer (which will be abbreviated simply as a “melting point difference” below) is preferably 10° C. or more and 140° C. or less. In other words, it is preferably a low-melting-point polymer having a melting point lower than the melting point of the high-melting-point polymer in the range of 10° C. or more and 140° C. or less. By setting the melting point difference to 10° C. or more, more preferably 20° C. or more, and still more preferably 30° C. or more, it is possible to effectively enhance the property of bonding fibers. In addition, by setting the melting point difference to 140° C. or less, more preferably 120° C. or less, and still more preferably 100° C. or less, it is possible to prevent the low-melting-point polymer component from bonding to a heat roll at the time of bonding, and the productivity from decreasing.

[0023] The melting point of the high-melting-point polymer in the present invention is preferably in the range of 160° C. or more and 320° C. or less. By setting the melting point to preferably 160° C. or more, more preferably 170° C. or more, and still more preferably 180° C. or more, for example, when the non-woven fabric is used as a house wrap material, it is possible to obtain a non-woven fabric having excellent form stability such that the form can be maintained even if processing of application of heat is performed. In addition, by setting the melting point to 320° C. or less, more preferably 300° C. or less, and still more preferably 280° C. or less, it is possible to prevent the productivity from decreasing due to a large amount of heat energy consumed for melting when the non-woven fabric is produced.

[0024] On the other hand, the melting point of the low-melting-point polymer in the composite fiber is preferably in the range of 150° C. or more and 310° C. or less while the melting point difference is ensured. By setting the melting point to 150° C. or more, more preferably 160° C. or more, and still more preferably 170° C. or more, when the non-woven fabric is used as a house wrap material, it is possible to obtain a non-woven fabric having excellent form stability such that the form can be maintained even if processing of application of heat is performed. In addition, by setting the melting point to 310° C. or less, more preferably 290° C. or less, and still more preferably 270° C. or less, a non-woven fabric having an excellent bonding property and an excellent mechanical strength when the non-woven fabric is produced can be easily obtained.

[0025] Further, in the present invention, the melting point of the thermoplastic resin is measured under the conditions of a heating rate of 20° C./min and a measurement temperature range of 30° C. to 350° C. using a differential scanning calorimeter (for example, “DSC-2” type manufactured by Perkin-Elmer Inc.), and a temperature exhibiting an extreme value in the obtained melting endothermic curve is taken as the melting point of the thermoplastic resin. In addition, with respect to a resin not exhibiting an extreme value in the melting endothermic curve obtained by a differential scanning calorimeter, a temperature at which the resin having been heated on a hot plate melts under microscopic observation is taken as the melting point.

[0026] When the thermoplastic resin is a polyester, examples of a combination of a pair of a polyester-based high-melting-point polymer and a polyester-based low-melting-point polymer (which may be listed below in the order of a polyester-based high-melting-point polymer/polyester-based low-melting-point polymer) include, for example, combinations of PET/PBT, PET/PTT, PET/polylactic acid, and PET/copolymerized PET, and among these, a combination of PET/copolymerized PET is preferably used since it has excellent spinnability. In addition, as a copolymer component in copolymerized PET, isophthalic acid-copolymerized PET is preferably used since it has particularly excellent spinnability.

[0027] Examples of the composite form of the composite fiber include, for example, a concentric core-sheath type, an eccentric core-sheath type, and a sea-island type, and among these, the concentric core-sheath type is preferable since fibers can be uniformly and firmly bonded. Furthermore, examples of the cross-sectional shape of the composite fiber include shapes such as a circular cross section, a flat cross section, a polygonal cross section, a multi-leafed cross section, and a hollow cross section. Among them, it is a preferable aspect to use a fiber having a circular cross-sectional shape as the cross-sectional shape of the composite fiber.

[0028] In addition, when the fiber containing a thermoplastic resin as a principal component is the above-mentioned composite fiber, the content ratio by mass of the high-melting-point polymer to the low-melting-point polymer is preferably in the range of 90:10 to 60:40, more preferably in the range of 85:15 to 70:30. When the content of the high-melting-point polymer is set to 60 mass % or more and 90 mass % or less, the non-woven fabric can have excellent durability. On the other hand, when the content of the low-melting-point polymer is 10 mass % or more and 40 mass % or less, fibers constituting the non-woven fabric are firmly bonded to each other, so a non-woven fabric excellent in mechanical strength can be obtained.

[0029] The average single fiber diameter of the fiber according to the present invention is preferably in the range of 10.0 μm or more and 26.0 μm or less. When the average single fiber diameter is set to 10.0 μm or more, preferably 10.5 μm or more, and more preferably 11.0 μm or more, a non-woven fabric excellent in mechanical strength can be obtained. On the other hand, by setting the average single fiber diameter to 26.0 μm or less, preferably 25.0 μm or less, and more preferably 24.0 μm or less, the uniformity of the non-woven fabric is improved, a non-woven fabric having a dense surface can be obtained, and for example, when the non-woven fabric is used as a house wrap material, a non-woven fabric having less surface unevenness can be obtained.

[0030] Further, in the present invention, a value obtained by using the following method is employed for an average single fiber diameter (μm) of the non-woven fabric.

- **[0031]** (i) Ten small-piece samples are randomly collected from a non-woven fabric.
- **[0032]** (ii) Photos of surfaces of the collected small-piece samples from which the thicknesses of the fibers can be measured with a scanning electron microscope or the like in a range of 500 times to 2,000 times magnification are taken.
- **[0033]** (iii) Ten fibers from each of the photos of the small-piece samples, that is, a total of 100 fibers, are arbitrarily selected, and the thicknesses of the fibers are measured. On the assumption that the fibers have a circular cross section, their thicknesses are defined as single fiber diameters (μm).
- **[0034]** (iv) The value calculated by rounding off the arithmetic mean to the second decimal place is defined as an average single fiber diameter (μm).

[Non-Woven Fabric]

[0035] The non-woven fabric of the present invention is made of a fiber containing the thermoplastic resin as a principal component. In addition, the non-woven fabric is preferably a long-fiber non-woven fabric that is generally excellent in productivity and incurs low cost. Among long-fiber non-woven fabrics, the non-woven fabric is more preferably a spunbond non-woven fabric that is more excellent in productivity and incurs low cost, and further can gain higher mechanical strength by bonding the temporary set web with a pair of thermocompression rolls.

[0036] The non-woven fabric of the present invention has a thickness CV value of 1.0% or more and 10.0% or less. When the thickness CV value is 1.0% or more, preferably 3.0% or more, and more preferably 5.0% or more, the adhesive force with respect to adhesive tapes can be further enhanced. On the other hand, when the thickness CV value is 10.0% or less, preferably 8.0% or less, and more preferably 7.0% or less, a non-woven fabric having sufficient mechanical strength is obtained.

[0037] Further, in the present invention, the thickness CV value (%) of the non-woven fabric refers to a value measured and calculated in the following method.

- **[0038]** (i) Five small-piece samples in which a cross section perpendicular to the thickness direction can be observed are collected from the non-woven fabric.
- **[0039]** (ii) Photos of the cross sections of the collected small-piece samples are taken at 100 times magnification by using a scanning electron microscope (SEM, for example, "VHX-D500" manufactured by KEYENCE CORPORATION, etc.).
- **[0040]** (iii) The thicknesses of the small-piece samples are measured every 100 μm in the entire width in the width direction of the photos taken, and the thickness CV value (%) is calculated from the arithmetic mean and the standard deviation thereof by using the following formula.

$$\text{Thickness } CV \text{ value } (\%) = (\text{standard deviation } (\mu\text{m}) \text{ of thicknesses of five small-piece samples})/(\text{arithmetic mean } (\mu\text{m}) \text{ of thicknesses of five small-piece samples}) \times 100.$$

- **[0041]** (iv) The thickness CV value (%) is similarly calculated for the five small-piece samples, and the arithmetic mean (%) of the thickness CV values of the five small-piece samples is rounded off to the second decimal place, and the resultant value is defined as the thickness CV value of the non-woven fabric.

[0042] The thickness CV value (%) of the non-woven fabric can be adjusted by making the form of the fibers constituting the non-woven fabric (such as a composite fiber) as described above, or by setting the conditions of the temperature and pressure of the rolls used when the fiber webs are bonded, the tension applied to the fiber webs at that time, and the like to be in the ranges described below.

[0043] In addition, in the present invention, the non-woven fabric has a porosity seen from the surface of 10% or more and 30% or less. When the porosity seen from the surface is 10% or more, preferably 13% or more, and more preferably 15% or more, the adhesive force with respect to adhesive tapes can be further enhanced. On the other hand, when the porosity seen from the surface is 30% or less, preferably 27% or less, and more preferably 25% or less, a non-woven fabric having sufficient mechanical strength is obtained.

[0044] The porosity seen from the surface (%) of the non-woven fabric can be adjusted by making the form of the fibers constituting the non-woven fabric (such as a composite fiber) as described above, or by setting the conditions of the temperature and pressure of the rolls used when the fiber webs are bonded, the tension applied to the fiber webs at that time, and the like to be in the ranges described below.

[0045] Furthermore, in the present invention, the non-woven fabric has a porosity seen from the surface CV value of 10% or more and 30% or less. When porosity seen from the surface CV value is set to 10% or more, preferably 13% or more, more preferably 15% or more, a non-woven fabric in which voids are appropriately arranged is obtained, and the adhesive force with respect to adhesive tapes can be further enhanced. On the other hand, when the porosity seen from the surface CV value is set to 30% or less, preferably 25% or less, and more preferably 20% or less, a non-woven fabric that is more homogeneous and has high mechanical strength is obtained.

[0046] Further, in the present invention, the porosity seen from the surface (%) and the porosity seen from the surface CV value (%) of the non-woven fabric refer to values measured and calculated by using the following method.

- **[0047]** (i) Ten small-piece samples whose surfaces can be observed are collected from the non-woven fabric.
- **[0048]** (ii) Photos of the surfaces of the collected small-piece samples are taken at 500 times magnification by using a scanning electron microscope (SEM, for example, "VHX-D500" manufactured by KEYENCE CORPORATION, etc.).
- **[0049]** (iii) The photos obtained by capturing the small-piece sample are prepared as grayscale images (8-bit images), and binarized by setting thresholds such that pixel values 0 to 127 are black and 128 to 255 are white.
- **[0050]** (iv) By using image analysis software (for example, "ImageJ" or the like), the proportion of black regions in the entire photos (white regions and black regions) is defined as a porosity seen from the surface.
- **[0051]** (v) The porosities seen from the surface (%) are similarly calculated for 10 small-piece samples, and the arithmetic mean (%) and the standard deviation (%) of the porosities seen from the surface of the 10 small-piece samples are calculated.
- **[0052]** (vi) The arithmetic mean (%) of the porosities seen from the surface of the 10 small-piece samples obtained in (v) is rounded off to the first decimal place, and the resultant value is defined as a porosity seen from the surface (%) of the non-woven fabric.
- **[0053]** (vii) The porosity seen from the surface CV value (%) is calculated from the arithmetic mean (%) and the standard deviation (%) of the porosities seen from the surface of the 10 small-piece samples obtained in (v) by using the following formula.

$$\text{Porosity seen from the surface } CV \text{ value } (\%) = (\text{standard deviation } (\%) \text{ of porosities seen from the surface of 10 small-piece samples}) / (\text{arithmetic mean } (\%) \text{ of the 10 small-piece samples } (\%)) \times 100.$$

- **[0054]** (viii) The porosity seen from the surface CV value (%) obtained in (vii) is rounded off to the first decimal place, and the resultant value is defined as a porosity seen from the surface CV value (%) of the non-woven fabric.

[0055] The porosity seen from the surface CV value (%) can be adjusted by making the form of the fibers constituting the non-woven fabric (such as a composite fiber) as described above, or by setting the conditions of the temperature and pressure of the rolls used when the fiber webs are bonded, the tension applied to the fiber webs at that time, and the like to be in the ranges described below.

[0056] The basis weight of the non-woven fabric of the present invention is preferably 20 g/m^2 or more and 60 g/m^2 or less. When the basis weight of the non-woven fabric is 20 g/m^2 or more, preferably 25 g/m^2 or more, more preferably 25 g/m^2 or more, a non-woven fabric that is excellent in mechanical strength can be obtained. On the other hand, when the basis weight of the non-woven fabric is 60 g/m^2 or less, preferably 55 g/m^2 or less, and more preferably 50 g/m^2 or less, a non-woven fabric that is lightweight and excellent in workability can be obtained.

[0057] Further, in the present invention, as for the basis weight of the non-woven fabric, a value measured according to the following procedure based on "6.2 Mass Per Unit Area" in the "General Test Method for Non-woven Fabric" of JIS L1913:2010 is employed.

- **[0058]** (i) Three test pieces of 25 cm×25 cm are collected per width of 1 meter of the sample.
- **[0059]** (ii) The masses (g) of the test pieces in the standard state are measured.
- **[0060]** (iii) The average value thereof is represented by mass per 1 m^2 (g/m^2) and rounded off to the first decimal place.

[0061] The apparent density of the non-woven fabric of the present invention is preferably 0.40 g/cm^3 or more and 0.70 g/cm^3 or less. When the apparent density of the non-woven fabric is set to 0.40 g/cm^3 or more, or more preferably 0.43 g/cm^3 or more, the surface of the non-woven fabric becomes smoother, and the mechanical strength can be further enhanced. On the other hand, when the apparent density of the non-woven fabric is set to 0.70 g/cm^3 or less, or more preferably 0.67 g/cm^3 or less, the anchor effect is easily exhibited between adhesive tapes and the non-woven fabric, and a non-woven fabric having an excellent adhesive force with respect to the adhesive tapes can be obtained.

[0062] Further, in the present invention, the apparent density of the non-woven fabric is assumed to be calculated by using the following method by adopting a thickness value measured according to the following procedure based on "5.1" "Testing Method for Woven and Knitted Fabrics" of JIS L1906:2000.

- **[0063]** (i) Thicknesses of 10 pieces are measured at equal intervals of 1 meter in the width direction of the non-woven fabric at a load of 10 kPa in units of 0.01 mm by using a pressurizer having a diameter of 10 mm.
- **[0064]** (ii) The average value of the 10 pieces is rounded off to the third decimal place to obtain a thickness (mm) of the non-woven fabric, and the thickness is calculated by using the following formula.

$$\text{Apparent density } (\text{g/cm}^3) = \text{basis weight } (\text{g/m}^2)/\text{thickness (mm)}/1000$$

[0065] Further, for the "basis weight (g/m^2)" in the above formula, the value of the basis weight obtained by using the above method is used.

[0066] The non-woven fabric of the present invention is particularly suitable for building material applications. That is, the building material of the present invention contains the non-woven fabric of the present invention.

[Production Method for Non-woven Fabric]

[0067] In the production method for a non-woven fabric of the present invention, it is preferable to bond non-woven webs by spinning a thermoplastic resin to form non-woven webs, and then setting the temperature of the non-woven webs to 100° C. or more and 160° C. or less such that a ratio A of the average single fiber diameter calculated in the following formula (1) is 0.85 or more and 0.95 or less.

$$A=(\text{Average single fiber diameter of non-woven webs before bonding } (\mu\text{m}))/(\text{Average single fiber diameter of non-woven fabric after bonding } (\mu\text{m})) \quad (1)$$

[0068] This method will be described in more detail below.

[0069] The non-woven fabric of the present invention is preferably produced by sequentially performing the following steps (a) to (c).

[0070] (a) A step of spinning a thermoplastic resin.

[0071] (b) A step of forming non-woven webs.

[0072] (c) A step of bonding the obtained non-woven webs.

[0073] Each of the steps will be described in more detail below.

(a) The Step of Spinning a Thermoplastic Resin

[0074] First, a thermoplastic resin is melted and extruded from a spinneret. In particular, when a composite fiber in which a low-melting-point polymer having a melting point lower than the melting point of a high-melting-point polymer is disposed around the high-melting-point polymer is used as a fiber containing a thermoplastic resin as a principal component, it is preferable that a polyester-based high-melting-point polymer and a polyester-based low-melting-point polymer be melted at a melting point or more and (melting point +70° C.) or less, respectively, and the fibers are spun out from pores with a spinneret having a spinneret temperature at a melting point or more and (melting point +70° C.) or less as a composite fiber in which a low-melting-point polymer having a melting point lower by 10° C. or more and 140° C. or less than the melting point of the high-melting-point polymer is disposed around the high-melting-point polymer.

[0075] The thermoplastic resin melted and extruded from the spinneret and spun is preferably spun into fibers having a circular cross-sectional shape.

(b) The Step of Forming Fiber Webs

[0076] Subsequently, fiber webs are formed from the fibers spun in step (a). Preferably, the spun fibers are sucked by an ejector, sprayed from a slit-like opening plate to a lower portion of the ejector, and further deposited on a moving net conveyor to form fiber webs.

[0077] In the production method for a non-woven fabric of the present invention, it is preferable to preheat the fiber webs collected on the net conveyor and to perform step (c) consecutively to step (b). In this preheating, a method in which the collected fiber webs are preheated by hot air from above the net conveyor, or a flat roll is placed on the net conveyor to preheat the space between the net conveyor and the flat roll is preferably used.

[0078] The preheating is preferably performed to set the temperature of the non-woven webs to 100° C. or more and 160° C. or less. By setting the temperature of the non-woven webs to 100° C. or more, preferably 110° C. or more, and more preferably 120° C. or more, the transportability of the non-woven webs can be improved. On the other hand, by setting the temperature of the non-woven webs to 160° C. or less, preferably 150° C. or less, and more preferably 140° C. or less, appropriate crystallization of the non-woven webs can be promoted.

(c) The Step of Bonding the Obtained Non-Woven Webs

[0079] Furthermore, the non-woven webs obtained in step (b) are bonded. Most of all, it is preferable to bond the non-woven webs such that the ratio A of the average single fiber diameter calculated by using the following formula (1) is 0.85 or more and 0.95 or less.

$$A=(\text{Average single fiber diameter of non-woven webs before bonding } (\mu\text{m}))/(\text{Average single fiber diameter of non-woven fabric after bonding } (\mu\text{m})) \quad (1)$$

[0080] It is preferable to bond the non-woven webs obtained in step (b) such that the temperature of the non-woven webs is in the above range and the ratio A is 0.85 or more and 0.95 or less. By bonding the non-woven webs such that the ratio A is preferably 0.85 or more and preferably 0.88 or more, a non-woven fabric having an excellent adhesive force with respect to adhesive tapes can be obtained. On the other hand, by bonding the non-woven webs such that the ratio A is preferably 0.95 or less or 0.92 or less, a non-woven fabric having excellent mechanical strength can be obtained.

[0081] Further, in the production method for a non-woven fabric of the present invention, a value obtained by the following method is employed as the average single fiber diameter (μm) of the non-woven webs before bonding of the formula (1), and a value obtained by the same method as the method for measuring and calculating the average single fiber diameter of the non-woven fabric is employed as the average single fiber diameter (um) of the non-woven fabric after bonding.

[0082] (i) Ten small-piece samples are randomly collected from the fiber webs obtained in step (b).

[0083] (ii) Photos of surfaces of the collected small-piece samples from which the thicknesses of the fibers can be measured with a scanning electron microscope or the like in a range of 500 times to 2,000 times magnification are taken.

[0084] (iii) Ten fibers from each of the photos of the small-piece samples, that is, a total of 100 fibers, are arbitrarily selected, and the thicknesses of the fibers are measured. On the assumption that the fibers have a circular cross section, their thicknesses are defined as single fiber diameters (um).

[0085] (iv) The value calculated by rounding off the arithmetic mean to the second decimal place is defined as an average single fiber diameter (um) of the non-woven webs before bonding.

[0086] The above-described ratio A can be adjusted by changing the discharge amount of the thermoplastic resin in step (a) or the pressure in step (b).

[0087] For the bonding, most of all, bonding by a heat roll or bonding by a combination of an ultrasonic oscillation device and a roll is preferable. In particular, bonding by a heat roll is the most preferable from the perspective of improving the strength of the non-woven fabric. The temperature for bonding by a heat roll is preferably lower than the melting point of the thermoplastic resin having the lowest melting point present on the surface of the fibers constituting the fiber webs by 5° C. or more and 60° C. or less. By setting the temperature for bonding to be lower by 5° C. or more, more preferably 10° C. or more than the melting point of the thermoplastic resin having the lowest melting point present on the fiber surface of the non-woven fabric by the heat roll, excessive bonding can be prevented. On the other hand, by lowering the temperature lower than the melting point by 60° C. or less, or more preferably 50° C. or less, a non-woven fabric uniformly bonded can be obtained.

[0088] In addition, the linear pressure of the heat roll for bonding is preferably 290 N/cm or more and 890 N/cm or less. By setting the linear pressure of the heat roll for bonding to 290 N/cm or more, or more preferably 390 N/cm or more, a non-woven fabric having sufficient mechanical strength can be obtained. By setting the linear pressure for bonding to 890 N/cm or less, or more preferably 790 N/cm or less, excessive bonding can be prevented.

EXAMPLES

[0089] Next, the non-woven fabric of the present invention will be specifically described based on examples. However, the present invention is not limited only to these examples. Unless otherwise described, each physical property is measured based on the methods described above.

[Measurement Methods]

(1) Melting Point of Thermoplastic Resin (° C.)

[0090] Measurement was performed under a condition of a temperature rising rate of 20° C./min using a differential scanning calorimeter "DSC-2 type" manufactured by Perkin-Elmer Inc., and a temperature at which an extreme value is given on the obtained melting endothermic curve was defined as a melting point.

(2) Intrinsic Viscosity (IV) of Thermoplastic Resin

[0091] The intrinsic viscosity (IV) of the thermoplastic resin was measured by using the following method.

[0092] Eight g of a sample was dissolved in 100 mL of ortho-chlorophenol, and its relative viscosity η_r was obtained by using an Ostwald viscometer at a temperature of 25° C. according to the following formula.

$$\eta_r = \eta/\eta_0 = (t \times d)/(t_0 \times d_0)$$

[0093] (Here, η represents the viscosity of a polymer solution; η_0 represents the viscosity of ortho-chlorophenol; t represents the dropping time (seconds) of the solution; d represents the density of the solution (g/cm^3); t_0 represents the dropping time (seconds) of ortho-chlorophenol; and d_0 represents the density (g/cm^3) of ortho-chlorophenol.)

[0094] Next, the intrinsic viscosity (IV) was calculated from the relative viscosity η_r according to the following formula.

$$\text{Intrinsic viscosity } (IV) = 0.0242\eta_r + 0.2634$$

(3) Average Single Fiber Diameter (μm) of Non-Woven Webs before Bonding

[0095] The average single fiber diameter of the non-woven webs before bonding was calculated by using the above method using "VHX-D500" manufactured by KEYENCE CORPORATION as a scanning electron microscope.

(4) Average Single Fiber Diameter (μm) of Non-Woven Fabric after Bonding

[0096] The average single fiber diameter of the non-woven fabric after bonding of the fabric according to the present invention was calculated by using the above-described method using "VHX-D500" manufactured by KEYENCE CORPORATION as a scanning electron microscope.

(5) Basis Weight (g/m^2) of Non-Woven Fabric

[0097] The basis weight of the non-woven fabric was calculated by the above method.

(6) Thickness (mm) of Non-Woven Fabric

[0098] The thickness of the non-woven fabric was evaluated by using the above-described method using "Teclock" (registered trademark) SM-114 manufactured by TECLOCK Co., Ltd. as a thickness gauge.

(7) Apparent Density (g/cm^3) of Non-Woven Fabric

[0099] The apparent density of the non-woven fabric was calculated by using the above method.

(8) Thickness CV Value (%) of Non-Woven Fabric

[0100] The thickness CV value of the non-woven fabric was calculated by using the above-described method using "VHX-D500" manufactured by KEYENCE CORPORATION as a scanning electron microscope.

(9) Porosity Seen from the Surface (%) and Porosity Seen from the Surface CV Value (%) of Non-Woven Fabric

[0101] The porosity seen from the surface and the porosity seen from the surface CV value of the non-woven fabric were calculated by using the above-described method using "VHX-D500" manufactured by KEYENCE CORPORATION as a scanning electron microscope.

(10) Adhesive Force (N/25 mm) Between Non-Woven Fabric and Adhesive Tape

[0102] Measurement was performed under the following conditions in accordance with "a) Procedure for testing an adhesive force to a test plate" and "g) Procedure for testing in a low temperature environment" in "10.3.2 Test procedure", and "10.4.5 Method 5: 180° Peeling adhesive force against a test plate in a low temperature environment" of "10.4 Measurement of peeling adhesive force measurement" of JIS Z0237:2022 "Adhesive Tape and Adhesive Sheet Test Method", and the peeling adhesive force was measured and evaluated. Further, in Tables 1 and 2, it is simply indicated as "Adhesive force with respect to an adhesive tape".

[0103] Test temperature: −10° C.

[0104] Adhesive tape used: Waterproof and airtight tape "Zenten (registered trademark) tape No. 692" manufactured by Nitto Denko Corporation

[0105] Tester: "AGS-X" manufactured by Shimadzu Corporation was used as a tensile tester (testing apparatus A).

[0106] Peeling speed 30±1 cm/min.

[Resin Used]

[0107] Next, the details of the resins used in examples and comparative examples will be described.

[0108] Polyester-based resin A: Polyethylene terephthalate (denoted as PET in Tables 1 and 2) dried to have a moisture content of 50 ppm by mass or less, and having an intrinsic viscosity (IV) of 0.65 and a melting point of 260° C.

[0109] Polyester-based resin B: A copolymerized polyethylene terephthalate (denoted as CO-PET in Tables 1 and 2) dried to a water content of 50 ppm by mass or less and having an intrinsic viscosity (IV) of 0.64, an isophthalic acid copolymerization ratio of 11 mol %, and a melting point of 230° C.

Example 1

(Step of Spinning Thermoplastic Resin)

[0110] The polyester-based resin A and the polyester-based resin B were melted at temperatures of 295° C. and 280° C., respectively. Then, the polyester-based resin A as a core component and the polyester-based resin B as a sheath component were spun from the pore at a spinneret temperature of 295° C. and a core: sheath mass ratio of 80:20, and then a filament having a circular cross-sectional shape was spun.

(Step of Forming Fiber Webs)

[0111] The obtained fibers were sucked by an ejector, and the fiber arrangement was regulated and deposited on a net conveyor whose movement speed was adjusted so that the basis weight of the obtained non-woven fabric was 25 g/m^2 by an opening plate to collect a fiber web. The average single fiber diameter of the fiber webs before bonding was 11.3 μm. Then, the collected fiber webs were preheated at 160° C.

(Step of Bonding Obtained Non-Woven Webs)

[0112] Continuously to the above step, the preheated non-woven webs were bonded by a calender roll composed of a pair of flat rolls under the condition that the surface temperature of each of the upper and lower flat rolls was 185° C. and the linear pressure was 686 N/cm. The average single fiber diameter of the non-woven fabric after bonding was 12.1 μm, and the ratio A of the average single fiber diameter was 0.93. In addition, the obtained non-woven fabric had a thickness CV value of 6.5%, a porosity seen from the surface of 25%, and a porosity seen from the surface CV value of 25%, a basis weight of 25 g/m^2, an apparent density of 0.42 g/cm^3, and an adhesive force with respect to an adhesive tape of 15.1 N/25 mm. The results are shown in Table 1.

Example 2

[0113] A non-woven fabric was obtained under the same conditions as in example 1 except that, in the (step of forming fiber webs), the moving speed of the net conveyor to adjust the basis weight of the non-woven fabric obtained to 25 g/m^2 was changed to adjust the moving speed of the net conveyor to 40 g/m^2, and preheating at 160° C. for the fiber webs was changed to preheating at 150° C. In example 2, the average single fiber diameter of the fiber webs before bonding was 11.3 μm, the average single fiber diameter of the non-woven fabric after bonding was 12.4 μm, and the ratio A of the average single fiber diameter was 0.91. In addition, the obtained non-woven fabric had a thickness CV value of 6.8%, a porosity seen from the surface of 21%, and a porosity seen from the surface CV value of 21%, a basis weight of 40 g/m^2, an apparent density of 0.57 g/cm^3, and an adhesive force with respect to an adhesive tape of 16.4 N/25 mm. The results are shown in Table 1.

Example 3

[0114] A non-woven fabric was obtained under the same conditions as in example 1 except that, in the (step of forming fiber webs), the moving speed of the net conveyor to adjust the basis weight of the non-woven fabric obtained to 25 g/m^2 was changed to adjust the moving speed of the net conveyor to 60 g/m^2, and preheating at 160° C. for the fiber webs was changed to preheating at 130° C. In example 3, the average single fiber diameter of the fiber webs before bonding was 11.3 μm, the average single fiber diameter of the non-woven fabric after bonding was 12.5 μm, and the ratio A of the average single fiber diameter was 0.90. In addition, the obtained non-woven fabric had a thickness CV value of 7.3%, a porosity seen from the surface of 15%, and a porosity seen from the surface CV value of 15%, a basis weight of 60 g/m^2, an apparent density of 0.60 g/cm^3, and an adhesive force with respect to an adhesive tape of 18.9 N/25 mm. The results are shown in Table 1.

Example 4

[0115] A non-woven fabric was obtained under the same conditions as in example 3 except that, in the (step of forming fiber webs), preheating at 130° C. for the fiber webs was changed to preheating at 100° C. In example 4, the average single fiber diameter of the fiber webs before bonding was 11.3 μm, the average single fiber diameter of the non-woven fabric after bonding was 13.1 μm, and the ratio A of the average single fiber diameter was 0.86. In addition, the obtained non-woven fabric had a thickness CV value of 6.5%, a porosity seen from the surface of 10%, and a porosity seen from the surface CV value of 29%, a basis weight of 60 g/m^2, an apparent density of 0.67 g/cm^3, and an adhesive force with respect to an adhesive tape of 15.7 N/25 mm. The results are shown in Table 1.

TABLE 1

		Example 1	Example 2	Example 3	Example 4
Fiber web	Type of resin of core component	PET	PET	PET	PET
	Type of resin of sheath component	CO-PET	CO-PET	CO-PET	CO-PET
	Mass ratio of core component [%]/mass ratio of sheath component [%]	80/20	80/20	80/20	80/20
	Average single fiber diameter (X) [μm]	11.3	11.3	11.3	11.3
	Preheating temperature [° C.]	160	150	130	100

TABLE 1-continued

		Example 1	Example 2	Example 3	Example 4
Bonding	Surface temperature of upper and lower calender rolls [° C.]	185	185	185	185
	Linear pressure of calender roll [N/cm]	686	686	686	686
Non-woven fabric	Average single fiber diameter (Y) [µm]	12.1	12.4	12.5	13.1
	Ratio of average single fiber diameters (A = X/Y) [—]	0.93	0.91	0.90	0.86
	Basis weight [g/m^2]	25	40	60	60
	Thickness [mm]	0.06	0.07	0.10	0.09
	Thickness CV value [%]	6.5	6.8	7.3	6.5
	Apparent density [g/cm^3]	0.42	0.57	0.60	0.67
	Porosity seen from surface [%]	25	21	15	10
	Porosity seen from surface CV value [%]	25	21	15	29
	Adhesive force with respect to adhesive tape [N/25 mm]	15.1	16.4	18.9	15.7

Comparative Example 1

[0116] A non-woven fabric was obtained under the same conditions as in example 1 except that, in the (step of forming fiber webs), preheating at 160° C. for the collected fiber webs was changed to preheating at 90° C. In comparative example 1, the average single fiber diameter of the fiber webs before bonding was 11.3 µm, the average single fiber diameter of the non-woven fabric after bonding was 13.3 µm, and the ratio of the average single fiber diameter was 0.85. In addition, the obtained non-woven fabric had a thickness CV value of 4.7%, a porosity seen from the surface of 12%, and a porosity seen from the surface CV value of 34%, a basis weight of 25 g/m^2, an apparent density of 0.63 g/cm^3, and an adhesive force with respect to an adhesive tape of 10.1 N/25 mm. The results are shown in Table 2.

Comparative Example 2

[0117] A non-woven fabric was obtained under the same conditions as in example 1 except that, in the (step of forming fiber webs), preheating at 160° C. for the collected fiber webs was changed to preheating at 170° C. In comparative example 2, the average single fiber diameter of the fiber webs before bonding was 11.3 µm, the average single fiber diameter of the non-woven fabric after bonding was 11.8 µm, and the ratio of the average single fiber diameter was 0.96. In addition, the obtained non-woven fabric had a thickness CV value of 10.3%, a porosity seen from the surface of 33%, and a porosity seen from the surface CV value of 27%, a basis weight of 25 g/m^2, an apparent density of 0.36 g/cm^3, and an adhesive force with respect to an adhesive tape of 12.4 N/25 mm. The results are shown in Table 2.

Comparative Example 3

[0118] A non-woven fabric was obtained under the same conditions as in example 2 except that, in the (step of forming fiber webs), preheating at 150° C. for the collected fiber webs was changed to preheating at 90° C. In comparative example 3, the average single fiber diameter of the fiber webs before bonding was 11.3 µm, the average single fiber diameter of the non-woven fabric after bonding was 13.4 µm, and the ratio of the average single fiber diameter was 0.84. In addition, the obtained non-woven fabric had a thickness CV value of 5.1%, a porosity seen from the surface of 11%, and a porosity seen from the surface CV value of 35%, a basis weight of 40 g/m^2, an apparent density of 0.80 g/cm^3, and an adhesive force with respect to an adhesive tape of 8.9 N/25 mm. The results are shown in Table 2.

Comparative Example 4

[0119] A non-woven fabric was obtained under the same conditions as in example 2 except that, in the (step of forming fiber webs), preheating at 150° C. for the collected fiber webs was changed to preheating at 180° C. In comparative example 4, the average single fiber diameter of the fiber webs before bonding was 11.3 µm, the average single fiber diameter of the non-woven fabric after bonding was 11.7 µm, and the ratio of the average single fiber diameter was 0.96. In addition, the obtained non-woven fabric had a thickness CV value of 14.3%, a porosity seen from the surface of 31%, and a porosity seen from the surface CV value of 28%, a basis weight of 40 g/m^2, an apparent density of 0.50 g/cm^3, and an adhesive force with respect to an adhesive tape of 10.4 N/25 mm. The results are shown in Table 2.

Comparative Example 5

[0120] A non-woven fabric was obtained under the same conditions as in example 3 except that, in the (step of forming fiber webs), preheating at 130° C. for the collected fiber webs was changed to preheating at 90° C. In comparative example 5, the average single fiber diameter of the fiber webs before bonding was 11.3 µm, the average single fiber diameter of the non-woven fabric after bonding was 13.4 µm, and the ratio of the average single fiber diameter was 0.84. In addition, the obtained non-woven fabric had a thickness CV value of 5.3%, a porosity seen from the surface of 7%, and a porosity seen from the surface CV value of 36%, a basis weight of 60 g/m^2, an apparent density of 0.75 g/cm^3, and an adhesive force with respect to an adhesive tape of 5.9 N/25 mm. The results are shown in Table 2.

Comparative Example 6

[0121] A non-woven fabric was obtained under the same conditions as in example 3 except that, in the (step of forming fiber webs), preheating at 130° C. for the collected fiber webs was changed to preheating at 180° C. In comparative example 6, the average single fiber diameter of the fiber webs before bonding was 11.3 µm, the average single fiber diameter of the non-woven fabric after bonding was

11.5 μm, and the ratio of the average single fiber diameter was 0.98. In addition, the obtained non-woven fabric had a thickness CV value of 18.5%, a porosity seen from the surface of 27%, and a porosity seen from the surface CV value of 31%, a basis weight of 60 g/m^2, an apparent density of 0.46 g/cm^3, and an adhesive force with respect to an adhesive tape of 8.2 N/25 mm. The results are shown in Table 2.

Comparative Example 7

[0122] A non-woven fabric was obtained under the same conditions as in example 1 except that, in the (step of forming fiber webs), the thickness of the obtained non-woven fabric set to 0.06 mm was adjusted to a thickness of 0.08 mm at the time of bonding. In comparative example 7, the average single fiber diameter of the fiber webs before bonding was 11.3 μm, the average single fiber diameter of the non-woven fabric after bonding was 11.6 μm, and the ratio of the average single fiber diameter was 0.97. In addition, the obtained non-woven fabric had a thickness CV value of 12.1%, a porosity seen from the surface of 34%, and a porosity seen from the surface CV value of 37%, a basis weight of 25 g/m^2, an apparent density of 0.31 g/cm^3, and an adhesive force with respect to an adhesive tape of 10.8 N/25 mm. The results are shown in Table 2.

TABLE 2-1

		Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Fiber web	Type of resin of core component	PET	PET	PET	PET
	Type of resin of sheath component	CO-PET	CO-PET	CO-PET	CO-PET
	Mass ratio of core component [%]/mass ratio of sheath component [%]	80/20	80/20	80/20	80/20
	Average single fiber diameter (X) [μm]	11.3	11.3	11.3	11.3
	Preheating temperature [° C.]	90	170	90	180
Bonding	Surface temperature of upper and lower calender rolls [° C.]	185	185	185	185
	Linear pressure of calender roll [N/cm]	686	686	686	686
Non-woven fabric	Average single fiber diameter (Y) [μm]	13.3	11.8	13.4	11.7
	Ratio of average single fiber diameters (A = X/Y) [—]	0.85	0.96	0.84	0.96
	Basis weight [g/m^2]	25	25	40	40
	Thickness [mm]	0.04	0.07	0.05	0.08
	Thickness CV value [%]	4.7	10.3	5.1	14.3
	Apparent density [g/cm^3]	0.63	0.36	0.80	0.50
	Porosity seen from surface [%]	12	33	11	31
	Porosity seen from surface CV value [%]	34	27	35	28
	Adhesive force with respect to adhesive tape [N/25 mm]	10.1	12.4	8.9	10.4

TABLE 2-2

		Comparative Example 5	Comparative Example 6	Comparative Example 7
Fiber web	Type of resin of core component	PET	PET	PET
	Type of resin of sheath component	CO-PET	CO-PET	CO-PET
	Mass ratio of core component [%]/mass ratio of sheath component [%]	80/20	80/20	80/20
	Average single fiber diameter (X) [μm]	11.3	11.3	11.3
	Preheating temperature [° C.]	90	180	160
Bonding	Surface temperature of upper and lower calender rolls [° C.]	185	185	185
	Linear pressure of calender roll [N/cm]	686	686	686
Non-woven fabric	Average single fiber diameter (Y) [μm]	13.4	11.5	11.6
	Ratio of average single fiber diameters (A = X/Y) [—]	0.84	0.98	0.97
	Basis weight [g/m^2]	60	60	25
	Thickness [mm]	0.08	0.13	0.08
	Thickness CV value [%]	5.3	18.5	12.1
	Apparent density [g/cm^3]	0.75	0.46	0.31
	Porosity seen from surface [%]	7	27	34

TABLE 2-2-continued

	Comparative Example 5	Comparative Example 6	Comparative Example 7
Porosity seen from surface CV value [%]	36	31	37
Adhesive force with respect to adhesive tape [N/25 mm]	5.9	8.2	10.8

[0123] The characteristics of the obtained non-woven fabric were as shown in Tables 1 and 2, and the spunbond non-woven fabrics of examples 1 to 4 were excellent in adhesive strength with respect to adhesive tapes, and exhibited good characteristics as non-woven fabrics. On the other hand, in the spunbond non-woven fabrics of comparative examples 1 to 6, the bonding was excessive and a filmed portion was not excellent in adhesive strength with respect to adhesive tapes, or crystallization of fibers was promoted by preheating, bonding of the non-woven fabrics was weak, the adhesive areas with respect to the adhesive tapes were poor, and the adhesive strength with the adhesive tapes was not excellent. Also in the spunbond non-woven fabric of comparative example 7, the bonding of the non-woven fabric was weak, the adhesive area with respect to the adhesive tape was poor, and the adhesive strength with respect to the adhesive tape was not excellent.

1. A non-woven fabric made from fibers containing a thermoplastic resin as a principal component, the non-woven fabric having a thickness CV value of 1.0% or more and 10.0% or less, a porosity seen from a surface of 10% or more and 30% or less, and a porosity seen from a surface CV value of 10% or more and 30% or less.

2. The non-woven fabric according to claim **1**, the non-woven fabric being used for a building material.

3. The non-woven fabric according to claim **1**, wherein an apparent density of the non-woven fabric is 0.40 g/cm^3 or more and 0.70 g/cm^3 or less.

4. The non-woven fabric according to claim **1**, wherein a basis weight of the non-woven fabric is 20 g/m^2 or more and 60 g/m^2 or less.

5. A production method for the non-woven fabric according to claim **1**, the production method comprising spinning a thermoplastic resin to form non-woven webs, then setting a temperature of the non-woven webs to 100° C. or more and 160° C. or less, and then bonding the non-woven webs such that a ratio A of an average single fiber diameter calculated in the following formula (1) is 0.85 or more and 0.95 or less,

$$A = (\text{Average single fiber diameter of non-woven webs before bonding}(\mu m))/(\text{Average single fiber diameter of non-woven fabric after bonding } (\mu m)) \quad (1)$$

6. A building material comprising the non-woven fabric according to claim **1**.

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