

DESCRIPTION

TITLE OF THE INVENTION: NONWOVEN FABRIC

TECHNICAL FIELD

[0001]

The present invention relates to a nonwoven fabric.

BACKGROUND ART

[0002]

Conventionally, in applications required to exhibit flame retardancy, a method in which a chemical having a flame retardant effect is kneaded into polyester, nylon, and cellulose-based fibers at the raw yarn stage and a method in which a chemical having a flame retardant effect is applied to polyester, nylon, and cellulose-based fibers in the post-processing have been adopted.

[0003]

As the flame retardant, halogen-based chemicals and phosphorus-based chemicals are generally used, but replacement of halogen-based chemicals with phosphorus-based chemicals have recently proceeded because of the environmental regulations. However, there are some phosphorus-based chemicals which do not reach the flame retardant effect of conventional halogen-based chemicals.

[0004]

As a method for imparting higher flame retardancy, there is a method in which a polymer exhibiting high flame retardancy is combined. For example, paper formed of a composite of a flame resistant yarn and a polyphenylene sulfide fiber (Patent Document 1) and a felt formed of a composite of a flame resistant yarn and a polyphenylene sulfide fiber (Patent Document 2) are known.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0005]

Patent Document 1: International Publication No.
2017/6807

Patent Document 2: Japanese Patent Laid-open
Publication No. 2013-169996

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006]

However, conventional flame retardant performance is attained by testing how hardly the material itself is burned or whether the material can shield the flames of the burner when being heated from one surface using a burner prescribed in JIS, and it cannot be said that the conventional flame retardant performance is sufficient to

prevent fire spread when the material is exposed to flames raging furiously like an actual fire for a long time or when other combustibles are present. In the method described in Patent Document 1, the flame can be shielded by the burner prescribed in JIS, but in a case in which the temperature of the heating source is higher or combustibles which ignite by temperature rise are in close contact with paper, ignition occurs when the temperature on the back side that is not hit by the flame rapidly rises and exceeds the ignition point of the combustibles which are in close contact with the back side that is not hit by the flame as polyphenylene sulfide carbonized by the flame transmits heat, and there is thus room for improvement. Patent Document 2 discloses felt formed of a composite of a flame resistant yarn and a polyphenylene sulfide fiber, but the felt density is low and there is a possibility that combustibles ignite when the air heated by the burner escapes from the felt gap, the ambient temperature on the opposite side that is not hit by the flame rapidly rises and the combustibles are arranged on the opposite side that is not hit by the flame.

[0007]

Accordingly, an object of the present invention is to provide a nonwoven fabric exhibiting high flame shielding performance and heat insulating property.

SOLUTIONS TO THE PROBLEMS

[0008]

The present invention adopts the following means in order to solve the above problems.

[0009]

(1) A nonwoven fabric including a non-melting fiber A having a high-temperature shrinkage rate of 3% or less and a thermal conductivity conforming to ISO22007-3 (2008) of 0.060 W/m·K or less and a thermoplastic fiber B having a LOI value conforming to JIS K 7201-2 (2007) of 25 or more, in which a density of the nonwoven fabric is more than 50 kg/m³ and less than 200 kg/m³.

[0010]

(2) The nonwoven fabric according to (1), in which a content of the non-melting fiber A is 15% to 70% by mass.

[0011]

(3) The nonwoven fabric according to (1) or (2), including a fiber C other than the non-melting fiber A and the thermoplastic fiber B at 20% by mass or less.

[0012]

(4) The nonwoven fabric according to any one of (1) to (3), in which the non-melting fiber A is a flame resistant fiber or a meta-aramid-based fiber.

[0013]

(5) The nonwoven fabric according to any one of (1) to (4), in which the thermoplastic fiber B is a fiber formed of a resin selected from the group consisting of anisotropic molten polyester, flame retardant poly(alkylene terephthalate), flame retardant poly(acrylonitrile butadiene styrene), flame retardant polysulfone, poly(ether-ether-ketone), poly(ether-ketone-ketone), polyether sulfone, polyarylate, polyarylene sulfide, polyphenylsulfone, polyetherimide, polyamide-imide, and any mixture of these resins.

[0014]

(6) The nonwoven fabric according to (5), in which the thermoplastic fiber B is a fiber containing a sulfur atom at 15% by mass or more.

[0015]

(7) The nonwoven fabric according to any one of (1) to (6), in which a density of the nonwoven fabric is 70 to 160 kg/m³.

EFFECTS OF THE INVENTION

[0016]

The nonwoven fabric of the present invention has the above-described configuration and thus exhibits high flame shielding performance and heat insulating property.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a diagram for explaining a combustion test to evaluate flame shielding performance and heat insulating property.

EMBODIMENTS OF THE INVENTION

[0018]

The present invention is a nonwoven fabric which includes a non-melting fiber A having a high-temperature shrinkage rate of 3% or less and a thermal conductivity conforming to ISO22007-3 (2008) of 0.060 W/m·K or less and a thermoplastic fiber B having a LOI value conforming to JIS K 7201-2 (2007) of 25 or more and has a density of more than 50 kg/m³ and less than 200 kg/m³.

[0019]

<<High-temperature shrinkage rate>>

In the present invention, the high-temperature shrinkage rate is a numerical value determined by the following equation from L0 and L1 attained as follows: a fiber, which is a raw material of the nonwoven fabric, is left to stand in a standard state (20°C, 65% of relative humidity) for 12 hours, then a tension of 0.1 cN/dtex is applied to the fiber, the original length L0 is measured, the fiber is exposed to a dry heat atmosphere at 290°C for

30 minutes without applying a load to the fiber, sufficiently cooled in the standard state (20°C, 65% of relative humidity), and a tension of 0.1 cN/dtex is applied to the fiber, and the length L1 is measured.

High-temperature shrinkage rate = $[(L0 - L1)/L0] \times 100$ (%)

The thermoplastic fiber melts when the flame approaches and heat is applied thereto, and the molten thermoplastic fiber spreads in a thin film shape along the surface of the non-melting fiber (aggregate). When the temperature further rises, both fibers will be eventually carbonized, but the high-temperature shrinkage rate of the non-melting fiber is 3% or less, thus the vicinity of the flame contact portion at which the temperature has increased hardly shrinks, fracture of the nonwoven fabric due to the thermal stress generated between the low temperature portion which is not in contact with the flame and the high temperature portion hardly occurs, and as a result, the flame can be shielded for a long time. It is preferable that the high-temperature shrinkage rate is low from this point, but the high-temperature shrinkage rate is preferably -5% or more since fracture of the nonwoven fabric due to thermal stress is caused even when the fiber does not shrink but significantly expands by heat. Among others, the high-temperature shrinkage rate is preferably

0% to 2%.

[0020]

<<Thermal conductivity>>

Thermal conductivity is a numerical value indicating the ease of heat conduction, and a small thermal conductivity means that the temperature rise at the unheated portion is small when the material is heated from one surface. A material having a thermal conductivity of 0.060 W/m·K or less measured by a method conforming to ISO22007-3 (2008) and using a felt having a weight per unit area of 200 g/m² and a thickness of 2 mm (density: 100 kg/m³) measured by a method conforming to JIS L 1913 (2010) as a test body hardly transmits heat, the temperature rise on the opposite side that is not heated can be suppressed when the material is formed into a nonwoven fabric and heated from one surface, and the possibility that the combustible ignites decreases even when a combustible is arranged on the opposite side. It is more preferable as the thermal conductivity is lower, but the upper limit thereof is about 0.020 W/m·K for available fiber materials.

[0021]

<<LOI value>>

The LOI value is the volume percentage of the minimum amount of oxygen required to sustain combustion of a substance in a mixed gas of nitrogen and oxygen, and it can

be said that it is less likely to burn as the LOI value is higher. Hence, a thermoplastic fiber having a LOI value conforming to JIS K 7201-2 (2007) of 25 or more hardly burns, and even if the thermoplastic fiber catches fire, the fire is extinguished immediately when the fire source is separated from the thermoplastic fiber, and a carbonized film is usually formed at the slightly flared portion, and this carbonized portion can prevent fire spread. It is more preferable as the LOI value is higher, but the upper limit of the LOI value for actually available substances is about 65.

[0022]

<<Ignition temperature>>

The ignition temperature is a spontaneous ignition temperature measured by a method conforming to JIS K 7193 (2010).

[0023]

<<Melting point>>

The melting point is a value measured by a method conforming to JIS K 7121 (2012). The melting point refers to the value of the melting peak temperature when heating performed at 10°C/min.

[0024]

<<Non-melting fiber A>>

In the present invention, the non-melting fiber A

refers to a fiber which does not liquefy but maintains its shape when being exposed to a flame, and those that do not liquefy or ignite at a temperature of 800°C are preferable and those that do not liquefy or ignite at a temperature of 1000°C or more are more preferable. Examples of the non-melting fiber having the high-temperature shrinkage rate in the range prescribed in the present invention include a flame resistant fiber, a meta-aramid-based fiber, and a glass fiber. The flame resistant fiber is a fiber obtained by subjecting a fiber selected from an acrylonitrile-based fiber, a pitch-based fiber, a cellulose-based fiber, a phenol-based fiber or the like as a raw material to a flame resistant treatment. These may be used singly or two or more of these may be used at the same time. Among these, flame resistant fibers, of which the high-temperature shrinkage rate is low and the carbonization proceeds by the oxygen shielding effect of the film formed by the thermoplastic fiber B to be described later at the time of flame contact, and the heat resistance at a high temperature is further improved, are preferable. Among various flame resistant fibers, an acrylonitrile-based flame resistant fiber is more preferably used as the fiber having a small specific gravity, flexibility, and excellent flame retardancy, and this flame resistant fiber is obtained by heating and oxidizing an acrylic fiber as a

precursor in high-temperature air. Examples of commercially available products include Pyromex (registered trademark) (manufactured by Toho Tenax Co., Ltd.) in addition to flame resistant fiber PYRON (registered trademark) (manufactured by Zoltek companies, Inc.) that is used in Examples and Comparative Examples to be described later. Generally, a meta-aramid-based fiber has a high high-temperature shrinkage rate and does not satisfy the high-temperature shrinkage rate prescribed in the present invention, but a meta-aramid-based fiber of which the high-temperature shrinkage rate is adjusted to be in the range of the high-temperature shrinkage rate prescribed in the present invention by a suppression treatment can be preferably used. The non-melting fiber preferably used in the present invention is used in a method in which the non-melting fiber is used singly or is combined with a different material, and the fiber length is preferably in a range of 30 to 120 mm, more preferably in a range of 38 to 70 mm. When the fiber length is in the range of 38 to 70 mm, it is possible to obtain a nonwoven fabric by a general needle punching method or a water-jet interlacing method and it is easy to combine with a different material. The thickness of the single fiber of the non-melting fiber is also not particularly limited, but the single fiber fineness is preferably in a range of 0.1 to 10 dtex from

the viewpoint of carding process-passing.

[0025]

When the content of the non-melting fiber in the nonwoven fabric is too low, the function as an aggregate is insufficient, and thus the mixing ratio of the non-melting fiber A in the nonwoven fabric is preferably 15% by mass or more, more preferably 20% by mass or more. The upper limit is preferably 70% by mass or less, and more preferably 60% by mass or less from the viewpoint of the productivity and strength of the nonwoven fabric.

[0026]

<<Thermoplastic fiber B>>

The thermoplastic fiber B used in the present invention is one of which the LOI value is in the range prescribed in the present invention and the melting point is lower than the ignition temperature of the non-melting fiber A, and specific examples thereof include fibers formed of thermoplastic resins selected from the group consisting of anisotropic molten polyester, flame retardant poly(alkylene terephthalate), flame retardant poly(acrylonitrile butadiene styrene), flame retardant polysulfone, poly(ether-ether-ketone), poly(ether-ketone-ketone), polyether sulfone, polyarylate, polyarylene sulfide, polyphenylsulfone, polyetherimide, polyamide-imide, and any mixture of these. These may be used singly

or two or more of these may be used at the same time. As the LOI value is in the range prescribed in the present invention, combustion in the air is suppressed and the polymer is likely to be carbonized. As the melting point is lower than the ignition temperature of the non-melting fiber A, the molten polymer forms a film on the surface of the non-melting fiber A and between the fibers and the film is further carbonized, thus the effect of shielding oxygen is enhanced, oxidative deterioration of the non-melting fiber A can be suppressed, and the carbonized film exerts excellent flame shielding performance. The melting point of the thermoplastic fiber B is lower than the ignition temperature of the non-melting fiber A by preferably 200°C or more, more preferably 300°C or more. Among these, polyphenylene sulfide fiber (hereinafter, also referred to as PPS fiber) is most preferable from the viewpoint of high LOI value, melting point range, and easy availability. Even a polymer of which the LOI value is not in the range prescribed in the present invention can be preferably used by being treated with a flame retardant as long as the LOI value of the polymer after the treatment is in the range prescribed in the present invention. PPS is most preferable since PPS contains a sulfur atom in the polymer structure or the flame retardant, thus generates sulfuric acid at the time of the thermal decomposition of the

polymer or flame retardant, and develops a mechanism for dehydration carbonization of the polymer substrate, and a sulfur-based flame retardant is preferable in the case of using a flame retardant. As the thermoplastic fiber B, it is preferable to use a fiber containing sulfur atoms at 15% by mass or more. Specific examples thereof include PPS and polyester to which a sulfur-based flame retardant is added. The upper limit is preferably 50% by mass or less from the viewpoint of fiber strength.

[0027]

The ratio of sulfur atom herein is determined by raising the temperature of about 10 mg of the sample from room temperature to 800°C at 10°C/min under an air stream condition, oxidizing and decomposing the thermoplastic fiber using a thermogravimetric analyzer, and quantitatively analyzing sulfur oxide in the decomposition gas by gas chromatography.

[0028]

The thermoplastic fiber B used in the present invention is used in a method in which the thermoplastic resin is used singly or is combined with a different material, and the fiber length is preferably in a range of 30 to 120 mm, more preferably in a range of 38 to 70 mm. When the fiber length is in the range of 38 to 70 mm, it is possible to obtain a nonwoven fabric by a general needle

punching method or a water-jet interlacing method and it is easy to combine with a different material. The thickness of the single fiber of the thermoplastic fiber B is also not particularly limited, but the single fiber fineness is preferably in a range of 0.1 to 10 dtex from the viewpoint of carding process-passing.

[0029]

The PPS fiber preferably used in the present invention is a synthetic fiber formed of a polymer of which the polymer structural unit includes $-(C_6H_4-S)-$ as the main structural unit. Typical examples of these PPS polymers include polyphenylene sulfide, polyphenylene sulfide sulfone, polyphenylene sulfide ketone, random copolymers and block copolymers of these, and any mixtures of these, etc. As a particularly preferred PPS polymer, a polyphenylene sulfide containing a p-phenylene sulfide unit represented by $-(C_6H_4-S)-$ as the main structural unit of the polymer preferably at 90% by mole or more is desirable. From the viewpoint of mass, polyphenylene sulfide containing a p-phenylene sulfide unit at 80% by mass, still more preferably at 90% by mass or more is desirable.

[0030]

The PPS fiber preferably used in the present invention is used in a method in which the PPS fiber is used singly or is combined with a different material, and

may be in the form of filament or staple. In the case of using the PPS fiber in the form of staple, the fiber length is preferably in a range of 30 to 120 mm, more preferably in a range of 38 to 70 mm. When the fiber length is in the range of 38 to 70 mm, it is possible to obtain a nonwoven fabric by a general needle punching method or a water-jet interlacing method and it is easy to combine with a different material. The thickness of the single fiber of PPS is also not particularly limited, but the single fiber fineness is preferably in a range of 0.1 to 10 dtex from the viewpoint of carding process-passing.

[0031]

The method for producing the PPS fiber used in the present invention is preferably a method in which a polymer having the above-mentioned phenylene sulfide structural unit is melted at a temperature equal to or higher than its melting point and spun from a spinneret to form a fiber. The spun fiber is an undrawn PPS fiber as it is. Most of the undrawn PPS fibers have an amorphous structure and a high fracture elongation. On the other hand, such fibers are inferior in dimensional stability due to heat, and thus drawn fibers in which the strength and thermal dimensional stability of the fibers are improved by hot drawing and orientation after spinning are commercially available. As PPS fibers, a plurality of PPS fibers such as "TORCON"

(registered trademark) (manufactured by TORAY INDUSTRIES, INC.) and "PROCON" (registered trademark) (manufactured by TOYOBO CO., LTD.) are in circulation.

[0032]

In the present invention, the undrawn PPS fiber and the drawn fiber can be used concurrently in the range satisfying the range of the present invention. Instead of the PPS fiber, it is of course possible to concurrently use a drawn fiber and an undrawn fiber of a fiber satisfying the range of the present invention.

[0033]

When the mixing ratio of the thermoplastic fibers B in the nonwoven fabric is too low, the thermoplastic fibers do not sufficiently spread in a film shape between the non-melting fibers of the aggregate, and thus the mixing ratio of the thermoplastic fibers B in the nonwoven fabric is preferably 10% by mass or more, more preferably 20% by mass or more. When the mixing ratio of the thermoplastic fiber B is too high, the carbonized portion is likely to be brittle at the time of flame contact and the flame shielding performance decreases, thus the upper limit of the mixing ratio is preferably 80% by mass or less, more preferably 70% by mass or less.

[0034]

<<Fiber C other than non-melting fiber A and

thermoplastic fiber B>>

A fiber C other than the non-melting fiber A and the thermoplastic fiber B may be contained in the nonwoven fabric in order to further impart specific performance. For example, a vinylon fiber, a polyester fiber other than the thermoplastic fiber B, a nylon fiber, and the like may be used in order to improve the hygroscopic property and water absorbing property of the nonwoven fabric. The mixing ratio of the fiber C is not particularly limited as long as the effect of the present invention is not impaired, and the mixing ratio of the fiber C other than the non-melting fibers A and the thermoplastic fibers B is preferably 20% by mass or less, more preferably 15% by mass or less. The lower limit in the case of using the fiber C is not particularly limited as long as the desired performance is imparted, but the lower limit is usually preferably about 10% by mass.

[0035]

The thickness of the nonwoven fabric of the present invention is measured by a method conforming to JIS L 1913 (2010) and is preferably 0.08 mm or more. When the thickness of the nonwoven fabric is too thin, sufficient flame shielding performance and heat insulating performance cannot be attained.

[0036]

As the morphology of the fibers used in the nonwoven fabric of the present invention, the number of crimp of the fibers is preferably 7 crimps/2.54 cm or more, still more preferably 12 crimps/2.54 cm or more in order to sufficiently attain entanglement of the fibers. The number of crimp in the present invention is measured conforming to JIS L 1015 (2000).

[0037]

The lengths of the short fibers of the non-melting fiber A and the thermoplastic fiber B are preferably the same as each other in order to obtain a more uniform nonwoven fabric. The same length does not have to be exactly the same, and the length of the thermoplastic fiber B may have a difference of about $\pm 5\%$ from the length of the non-melting fiber A. From this viewpoint, the fiber length of the non-melting fiber and the length of the thermoplastic fiber B or the fiber C are all preferably in a range of 30 to 120 mm, more preferably in a range of 38 to 70 mm.

[0038]

The nonwoven fabric of the present invention is produced by a needle punching method, a water-jet interlacing method or the like using the above short fibers. The structure of the nonwoven fabric is not limited as long as it is in the range prescribed in the

present invention, but the density of the nonwoven fabric is required to be more than 50 kg/m³ and less than 200 kg/m³, and is preferably 55 to 180 kg/m³, more preferably 70 to 160 kg/m³, particularly preferably 75 to 160 kg/m³. The density is calculated by dividing the weight of a 30 cm square sample by the thickness measured by a method conforming to JIS L 1913 (2010).

[0039]

The density of the nonwoven fabric is important for the nonwoven fabric of the present invention to exhibit both excellent flame shielding performance and heat insulating property. The heat transmission includes that generated through a solid substance, that generated through a gas, and that caused by radiation. When the density increases, the volume occupied by the fibers constituting the nonwoven fabric in the unit volume increases and the contact points between the fibers increase, and thus the thermal conductivity increases. Specifically, when the density is more than 200 kg/m³, heat is likely to be transmitted by the polyphenylene sulfide carbonized by the flame and the temperature on the back side that is not hit by the flame is likely to rapidly rise. On the other hand, when the density is less than 50 kg/m³, when one surface of the nonwoven fabric is heated, the heated high-temperature air is likely to escape to the opposite side of the

nonwoven fabric, heat conduction due to the flow of air is promoted, and the temperature on the back side that is not hit by the flame is likely to rapidly rise. In other words, by setting the density of the nonwoven fabric to a range more than 50 kg/m³ and less than 200 kg/m³, the PPS fibers appropriately forms a carbonized film to exert a flame shielding performance at the portion hit by the flame and an appropriately fine air layer is maintained in the thickness direction of the nonwoven fabric, as a result, heat conduction through solid substances and gas is suppressed and excellent heat insulating property is exhibited. That is, it is important that the density value is in a certain range. On the other hand, heat transmission by radiation is suppressed when the density is high. In other words, heat transmission by radiation is further suppressed as the reciprocal of the density is smaller. Considering the above, excellent heat insulating property is achieved by setting the sum of the density and the reciprocal of the density, namely, {density + (1/density)} to be in an appropriate range. The degrees of influence of the heat transmission effect through solid substances, heat transmission effect through gas, and heat transmission effect by radiation are different from one another, strictly speaking, it is thus necessary to experimentally determine the weighting of each of the

density term and the $(1/\text{density})$ term, but in the range of the present invention, the value of density (kg/m^3) + $1/\text{density}$ (kg/m^3) is preferably 20 to 400, more preferably 25 to 350, still more preferably 30 to 300 in order to attain excellent flame shielding performance and heat insulating property. As the thickness of the nonwoven fabric holding such a structure increases, the heat insulating property is proportionally improved.

[0040]

After the nonwoven fabric is produced, heat setting may be performed using a stenter or calendering may be performed in the range prescribed in the present invention. As a matter of course, the gray fabric may be used as it is. The setting temperature is preferably a temperature at which the effect of suppressing the high-temperature shrinkage rate is attained, and is preferably 160°C to 240°C , more preferably 190°C to 230°C . The calendering is to adjust the thickness, namely the density of the nonwoven fabric, and the speed, pressure, and temperature for calendering are not limited as long as a nonwoven fabric having physical properties in the ranges prescribed in the present invention is obtained.

[0041]

The nonwoven fabric of the present invention thus obtained is excellent in flame shielding performance and

heat insulating property and exerts a fire spread preventing effect particularly by being combined with a combustible, thus is suitable for use in clothing materials, wall materials, floor materials, ceiling materials, covering materials, and the like that are required to exhibit flame retardancy, and is particularly suitable for use in fireproof protective clothing and fire spread preventive covering materials for urethane sheet materials and fire spread prevention for bed mattresses of motor vehicles and aircraft.

EXAMPLES

[0042]

Next, the present invention will be specifically described based on Examples. However, the present invention is not limited to only these Examples. Various changes and modifications can be made without departing from the technical scope of the present invention. Incidentally, the methods for measuring various properties used in the present Examples are as follows.

[0043]

[Weight per unit area]

The weight of a 30 cm square sample was measured and expressed in weight per 1 m² (g/m²).

[0044]

[Thickness]

The thickness was measured conforming to JIS L 1913 (2010).

[0045]

[Evaluation on flame shielding performance and heat insulating property]

Soft urethane foam commercially available from Fuji Gomu co., Ltd. is cut into a length of 20 cm, a width of 20 cm, and a thickness of 20 cm to obtain urethane foam 1. The nonwoven fabric 2 of the present invention is covered on the surface of the urethane foam 1, and the place indicated by 3 in Fig. 1 is sewn with a cotton thread to form the sewn portion 3. The sample is heated using a burner 4 for 2 minutes at a distance of 5 cm from the sample. As the burner 4, Power Torch RZ-730 manufactured by Shinfuji Burner co., ltd. was used. The temperature of the flame is adjusted to 1000 degrees using a thermocouple. After 2 minutes of heating, the flame of the burner was extinguished, and the state of the nonwoven fabric and the internal urethane was observed. A case in which a hole is not formed in the nonwoven fabric after 2 minutes of heating is evaluated "to exhibit flame shielding performance" and graded A. A case in which a hole is formed in the nonwoven fabric during 2 minutes of heating and the flame reaches the internal urethane foam is

evaluated "not to exhibit flame shielding performance" and graded F. A case in which the flame of the burner is extinguished after 2 minutes of heating, the sample is cooled at room temperature for 10 minutes, and the internal urethane foam is flashed and the fire spreads or the urethane foam is completely burned is evaluated "not to exhibit heat insulating property" for the urethane foam and graded F. A case in which the fire is self-extinguished after the flame of the burner is extinguished and the urethane foam remains is graded B, and a case in which the fire is self-extinguished and the weight reduction rate of urethane foam is 5% by mass or less is graded A.

[0046]

Next, terms in the following Examples and Comparative Examples will be described.

[0047]

<<Drawn fiber of PPS fiber>>

As a drawn PPS fiber, "TORCON" (registered trademark), product number S371 (manufactured by TORAY INDUSTRIES, INC.) having a single fiber fineness of 2.2 dtex (diameter: 14 μ m) and a cut length of 51 mm was used. This PPS fiber has a LOI value of 34, a melting point of 284°C, and a number of crimp of 11 crimps/2.54 cm. The ratio of sulfur atoms in the fiber was 26.2% by mass.

[0048]

<<Flame resistant yarn>>

A 1.7 dtex flame resistant fiber PYRON (manufactured by Zoltek companies, Inc.) cut into 51 mm was used. The high-temperature shrinkage rate of PYRON was 1.6%. When PYRON was heated by a method conforming to JIS K 7193 (2010), ignition was not observed even at 1000°C, and the ignition temperature thereof was 1000°C or more. The thermal conductivity was 0.042 W/m·K. The number of crimp is 10 crimps/2.54 cm.

<<Polyethylene terephthalate (PET) fiber>>

As a drawn PET fiber, "TETORON" (registered trademark) (manufactured by TORAY INDUSTRIES, INC.) having a single fiber fineness of 2.2 dtex (diameter: 14 μm) and a cut length of 51 mm was used. This PET fiber has an LOI value of 22 and a melting point of 267°C. The number of crimp is 17 crimps/2.54 cm. A sulfur atom was not detected in the fiber.

[0049]

<<Carbon fiber>>

"TORAYCA" (registered trademark) (manufactured by TORAY INDUSTRIES, INC.) with a diameter of 30 microns cut into 51 mm was used. The thermal conductivity was 8.4 W/m·K.

[0050]

[Example 1]

(Fabrication of nonwoven fabric)

The drawn fiber of PPS fiber and the flame resistant yarn were mixed together using an opener, then were further mixed together using a blower, and then passed through a carding machine to fabricate a web. The web obtained was stacked using a cross-lapper and formed into a felt using a water-jet interlacing machine to obtain a nonwoven fabric including a drawn fiber of PPS fiber and a flame resistant yarn. The weight mixing ratio of the drawn fiber of PPS fiber to the flame resistant yarn in the nonwoven fabric was 60 : 40, the weight per unit area of the nonwoven fabric was 100 g/m², and the thickness thereof was 1.21 mm.

[0051]

(Evaluation on flame shielding performance and heat insulating property)

The flame did not penetrate the nonwoven fabric for 2 minutes, the internal urethane foam did not catch fire, and the weight reduction rate of the urethane foam was 0.7% by mass, indicating that the nonwoven fabric exhibited sufficient flame shielding performance and heat insulating property.

[0052]

[Example 2]

The weight mixing ratio of the drawn fiber of PPS fiber to the flame resistant yarn in the nonwoven fabric

was changed to 90 : 10 in Example 1 to obtain a nonwoven fabric having a weight per unit area of 100 g/m² and a thickness of 1.53 mm.

[0053]

The flame did not penetrate the nonwoven fabric for 2 minutes, the internal urethane foam did not catch fire, and the weight reduction rate of the urethane foam was 15.2% by mass, indicating that the present nonwoven fabric exhibited sufficient flame shielding performance and heat insulating property.

[0054]

[Example 3]

The weight mixing ratio of the drawn fiber of PPS fiber to the flame resistant yarn in the nonwoven fabric was changed to 30 : 70 in Example 1 to obtain a nonwoven fabric having a weight per unit area of 100 g/m² and a thickness of 1.64 mm.

[0055]

The flame did not penetrate the nonwoven fabric for 2 minutes, the internal urethane foam did not catch fire, and the weight reduction rate of the urethane foam was 1.2% by mass, indicating that the present nonwoven fabric exhibited sufficient flame shielding performance and heat insulating property.

[0056]

[Example 4]

The weight mixing ratio of the drawn fiber of PPS fiber to the flame resistant yarn in the nonwoven fabric was changed to 10 : 90 in Example 1 to obtain a nonwoven fabric having a weight per unit area of 100 g/m² and a thickness of 1.63 mm.

[0057]

The flame did not penetrate the nonwoven fabric for 2 minutes, the internal urethane foam did not catch fire, and the weight reduction rate of the urethane foam was 5.6% by mass, indicating that the present nonwoven fabric exhibited sufficient flame shielding performance and heat insulating property.

[0058]

[Example 5]

The weight per unit area of the nonwoven fabric was changed to 50 g/m² in Example 1 to obtain a nonwoven fabric having a thickness of 0.89 mm.

[0059]

The flame did not penetrate the nonwoven fabric for 2 minutes, the internal urethane foam did not catch fire, and the weight reduction rate of the urethane foam was 3.2% by mass, indicating that the present nonwoven fabric exhibited sufficient flame shielding performance and heat insulating property.

[0060]

[Example 6]

The weight per unit area of the nonwoven fabric was changed to 120 g/m² in Example 1 to obtain a nonwoven fabric having a thickness of 1.91 mm.

[0061]

The flame did not penetrate the nonwoven fabric for 2 minutes, the internal urethane foam did not catch fire, and the weight reduction rate of the urethane foam was 0.3% by mass, indicating that the present nonwoven fabric exhibited sufficient flame shielding performance and heat insulating property.

[0062]

[Example 7]

The felting method was changed to needle punching in Example 1 to obtain a nonwoven fabric including a drawn fiber of PPS fiber and a flame resistant yarn. The weight mixing ratio of the drawn fiber of PPS fiber to the flame resistant yarn in the nonwoven fabric was 60 : 40, the weight per unit area of the nonwoven fabric was 300 g/m², and the thickness thereof was 3.12 mm.

[0063]

The flame did not penetrate the nonwoven fabric for 2 minutes, the internal urethane foam did not catch fire, and the weight reduction rate of the urethane foam was 0.1% by

mass, indicating that the present nonwoven fabric exhibited sufficient flame shielding performance and heat insulating property.

[0064]

[Example 8]

The nonwoven fabric obtained in Example 7 passed through a resin roll-resin roll calender one time at room temperature, a linear pressure of 50 N/cm, and a roll rotation speed of 5 m/min to obtain a nonwoven fabric having a weight per unit area of 300 g/m² and a thickness of 1.87 mm.

[0065]

The flame did not penetrate the nonwoven fabric for 2 minutes, the internal urethane foam did not catch fire, and the weight reduction rate of the urethane foam was 0.1% by mass, indicating that the present nonwoven fabric exhibited sufficient flame shielding performance and heat insulating property.

[0066]

[Example 9]

A PET fiber was mixed other than the drawn fiber of PPS fiber and the flame resistant yarn and the weight mixing ratio of the drawn fiber of PPS fiber to the flame resistant yarn and the PET fiber was set to 40 : 40 : 20 in Example 1 to obtain a nonwoven fabric having a weight per

unit area of 100 g/m² and a thickness of 1.30 mm.

[0067]

The flame did not penetrate the nonwoven fabric for 2 minutes, the internal urethane foam did not catch fire, and the weight reduction rate of the urethane foam was 4.7% by mass, indicating that the present nonwoven fabric exhibited sufficient flame shielding performance and heat insulating property.

[0068]

[Comparative Example 1]

A 1.7 dtex flame resistant fiber PYRON (manufactured by Zoltek companies, Inc.), a 1.0 dtex PPS drawn fiber, "TORCON" (registered trademark) (manufactured by TORAY INDUSTRIES, INC.), and a 3.0 dtex PPS undrawn fiber "TORCON" (registered trademark) (manufactured by TORAY INDUSTRIES, INC.) were each cut into 6 mm and these flame resistant fiber, undrawn fiber of PPS fiber, and drawn fiber of PPS fiber were prepared at a weight ratio of 40 : 30 : 30 (namely, flame resistant yarn to PPS fiber = 40 : 60). These were dispersed in water to prepare a dispersion. Wet paper was fabricated from the dispersion using a handmade paper machine. The wet paper was heated and dried at 110°C for 70 seconds using a rotary dryer, and subsequently heated and pressed one time for each side at a linear pressure of 490 N/cm and a roll rotation speed of 5

m/min a total of two times by setting the surface temperature of the iron roll to 200°C to obtain a nonwoven fabric. The nonwoven fabric obtained had a weight per unit area of 100 g/m² and a thickness of 0.15 mm.

[0069]

The flame did not penetrate the nonwoven fabric for 2 minutes, but the present nonwoven fabric ignited from the internal urethane foam after 1 minute and 30 seconds of heating, and the urethane foam was completely burned in 10 minutes after the flame of the burner was extinguished.

[0070]

[Comparative Example 2]

The weight per unit area of the nonwoven fabric was changed to 50 g/m² and the thickness thereof was changed to 10 mm in Example 7 to obtain a nonwoven fabric.

[0071]

The flame did not penetrate the nonwoven fabric for 2 minutes, but the present nonwoven fabric ignited from the internal urethane foam after 1 minute of heating, and the urethane foam was completely burned in 10 minutes after the flame of the burner was extinguished.

[0072]

[Comparative Example 3]

A carbon fiber was used instead of the flame resistant yarn and the ratio of the drawn PPS fiber to the

carbon fiber was set to 60 : 40 in Example 7 to obtain a nonwoven fabric having a weight per unit area of 100 g/m² and a thickness of 1.89 mm.

[0073]

The flame did not penetrate the nonwoven fabric for 2 minutes, but the present nonwoven fabric ignited from the internal urethane foam after 1 minute and 50 seconds of heating, and the urethane foam was completely burned in 10 minutes after the flame of the burner was extinguished.

[0074]

[Table 1]

	Nonwoven fabric design												Performance
	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Comparative Example 1	Comparative Example 2	Comparative Example 3	
Nonwoven fabric design	Nonwoven fabric producing method	Water-jet interlacing	Water-jet interlacing	Water-jet interlacing	Water-jet interlacing	Water-jet interlacing	Needle punching	Needle punching + calendaring	Water-jet interlacing	Wet papermaking	Needle punching	Needle punching	
	Non-melting fiber A Mixing ratio (%)	Flame resistant yarn 40wt%	Flame resistant yarn 10wt%	Flame resistant yarn 90wt%	Flame resistant yarn 40wt%	Flame resistant yarn 40wt%	Flame resistant yarn 40wt%	Flame resistant yarn 40wt%	Flame resistant yarn 40wt%	Flame resistant yarn 40wt%	Flame resistant yarn 40wt%	None	
	Thermoplastic fiber B Mixing ratio (%)	PPS fiber 60wt%	PPS fiber 90wt%	PPS fiber 30wt%	PPS fiber 10wt%	PPS fiber 60wt%	PPS fiber 60wt%	PPS fiber 60wt%	PPS fiber 40wt%	PPS fiber 60wt%	PPS fiber 60wt%	PPS fiber 60wt%	
	Other fiber C Mixing ratio (%)	None	None	None	None	None	None	None	PET fiber 20wt%	None	None	Carbon fiber 40wt%	
	Weight per unit area (g/m²)	100	100	100	100	50	120	300	300	100	100	50	100
	Thickness (mm)	1.21	1.53	1.64	1.63	0.89	1.91	3.12	1.87	1.3	0.15	10	1.89
	Density (kg/m³)	83	65	61	61	56	63	96	160	77	667	5	53
	Density+ (1/density)	82.7	65.4	61.0	61.4	56.2	62.8	96.2	160.4	76.9	666.7	5.2	52.9
	Flame shielding performance	A With flame shielding performance	A With flame shielding performance	A With flame shielding performance	A With flame shielding performance	A With flame shielding performance	A With flame shielding performance	A With flame shielding performance	A With flame shielding performance	A With flame shielding performance	A With flame shielding performance	A With flame shielding performance	A With flame shielding performance
Heat insulating property	A 0.7wt%	B 15.2wt%	A 1.2wt%	B 5.6wt%	A 3.2wt%	A 0.3wt%	A 0.1wt%	A 0.1wt%	A 4.7wt%	F Flashing of urethane Complete burning of urethane	F Flashing of urethane Complete burning of urethane	F Flashing of urethane Complete burning of urethane	

INDUSTRIAL APPLICABILITY

[0075]

The present invention is effective in fire spread prevention, is suitable for use in clothing materials, wall materials, floor materials, ceiling materials, covering materials, and the like that are required to exhibit flame retardancy, and is particularly suitable for use in fireproof protective clothing and fire spread preventive covering materials for urethane sheet materials and fire spread prevention for bed mattresses of motor vehicles and aircraft.

DESCRIPTION OF REFERENCE SIGNS

[0076]

- 1: Urethane foam
- 2: Nonwoven fabric
- 3: Sewn portion
- 4: Burner

CLAIMS

1. A nonwoven fabric comprising a non-melting fiber A having a high-temperature shrinkage rate of 3% or less and a thermal conductivity conforming to ISO22007-3 (2008) of 0.060 W/m·K or less and a thermoplastic fiber B having a LOI value conforming to JIS K 7201-2 (2007) of 25 or more, wherein a density of the nonwoven fabric is more than 50 kg/m³ and less than 200 kg/m³.

2. The nonwoven fabric according to claim 1, wherein a content of the non-melting fiber A is 15% to 70% by mass.

3. The nonwoven fabric according to claim 1 or 2, comprising a fiber C other than the non-melting fiber A and the thermoplastic fiber B at 20% by mass or less.

4. The nonwoven fabric according to any one of claims 1 to 3, wherein the non-melting fiber A is a flame resistant fiber or a meta-aramid-based fiber.

5. The nonwoven fabric according to any one of claims 1 to 4, wherein the thermoplastic fiber B is a fiber formed of a resin selected from the group consisting of anisotropic molten polyester, flame retardant poly(alkylene

terephthalate), flame retardant poly(acrylonitrile butadiene styrene), flame retardant polysulfone, poly(ether-ether-ketone), poly(ether-ketone-ketone), polyether sulfone, polyarylate, polyarylene sulfide, polyphenylsulfone, polyetherimide, polyamide-imide and any mixture of these resins.

6. The nonwoven fabric according to claim 5, wherein the thermoplastic fiber B is a fiber containing a sulfur atom at 15% by mass or more.

7. The nonwoven fabric according to any one of claims 1 to 6, wherein a density of the nonwoven fabric is 70 to 160 kg/m³.