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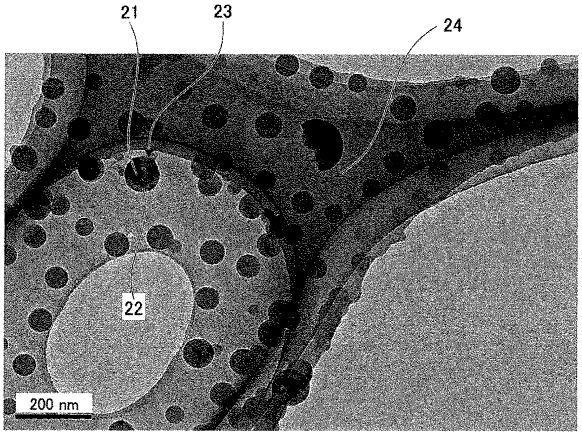
(54) INFRARED ABSORBING FIBER AND FIBER PRODUCT

(57) An infrared absorbing fiber including: a fiber; and organic-inorganic hybrid infrared absorbing particles, is provided. The organic-inorganic hybrid infrared absorbing particles include infrared absorbing particles and a coating resin that covers at least a part of a surface of the infrared absorbing particles. The organic-inorganic hybrid infrared absorbing particles are located in one or more parts selected from an interior of the fiber and a surface of the fiber.

FIG.2



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Description

Technical Field

[0001] The present invention relates to an infrared absorbing fiber and a fiber product.

Background Art

[0002] Various thermal clothing, interior goods, and leisure goods with enhanced heat retention effect have been devised and put into practical use. There are roughly two methods for increasing the heat retention effect that have been put into practical use.

[0003] The first method is to maintain heat retention by reducing the dissipation of heat generated from the human body. Specifically, for example, methods of physically increasing the air layer in the cold weather clothing by controlling the weaving structure in the cold weather clothing or making the fibers used hollow or porous have been adopted.

[0004] The second method is to improve heat retention by accumulating heat by active methods such as radiating the heat generated from the human body back to the human body and converting part of the sunlight received by the cold weather clothing into heat. Specifically, for example, in the cold weather clothing, methods of chemically or physically processing the entire clothing or fibers constituting the cold weather clothing have been adopted.

[0005] As described above, the first method was to increase the air space in the clothing, thicken the fabric, make the fabric finer, or darken the color. Specific examples include winter clothing such as sweaters, and clothing that is often used as clothing for sports in winter and that has batting inserted between the outer fabric and the lining to maintain heat retention due to the thickness of the air layer in the batting. However, when the air layer is increased by adding the batting or the like, the clothing becomes heavy and bulky, causing problems for sports that require ease of movement. In order to solve such problems, in recent years, the second method described above, which actively and effectively utilizes heat generated inside or from outside, has been adopted.

[0006] As one method of implementing the second method, a method is known in which a metal such as aluminum or titanium is deposited on the lining or the like of clothing to reflect radiant heat emitted from the body on the metal deposited surface, thereby actively preventing the dissipation of heat. However, in such a method, not only a considerable cost is required for depositing the metal onto clothing, but also the yield deteriorates due to uneven deposition and the like, resulting in an increase in the price of the product itself.

[0007] As another method for implementing the second method, a method in which ceramic particles such as alumina, zirconia, and magnesia are kneaded into the fiber itself, utilizing the far-infrared radiation effect and the effect of converting light into heat of the ceramic particles, that is, a method of actively incorporating external energy, has been proposed.

[0008] For example, PTL 1 discloses a heat ray radiating fiber characterized in that the fiber includes one or more types of inorganic fine particles having a heat ray radiating property that contain at least one of metals having a thermal conductivity of 0.3 $\mathrm{kcal/m^2 \cdot sec \cdot {}^\circ C}$ or more and metal ions. Examples of the inorganic fine particles having a heat ray radiating property include silica and barium sulfate.

[0009] PTL 2 discloses a heat retention composite fiber including: a thermoplastic polymer A having a melting point of 110°C or more; and a thermoplastic polymer B having a melting point of 15 to 50°C, a temperature-lowering crystallization temperature of 40°C or less, and a crystallization heat of 10 mJ/mg or more, wherein the composite fiber includes ceramic fine particles having a far-infrared radiation ability of 0.1 to 20 wt% relative to the weight of the fiber, and wherein the polymer A covers the surface of the fiber.

[0010] PTL 3 discloses an infrared absorbing processed fiber product in which a binder resin containing an infrared absorbing agent consisting of at least one or more predetermined amino compounds is dispersed and adhered to the fiber product.

[0011] PTL 4 discloses a near infrared absorbing processing method for a cellulose fiber structure in which, by dyeing with a combination of a dye that absorbs more in a near-infrared region than a black dye and other dyes, a spectral reflectance of a fabric is 65% or less within a range of 750 to 1,500 nm as a degree of near infrared absorption.

[0012] The applicant of the present invention has proposed fibers containing boride fine particles, tungsten oxide fine particles, composite tungsten oxide fine particles, and fiber products obtained by processing the fibers, in PTLs 5, 6, and 7.

Citation List

Patent Literature

[0013]

PTL 1:

Japanese Laid-Open Patent Publication No. H11-279830
PTL 2:
Japanese Laid-Open Patent Publication No. H5-239716
PTL 3:
Japanese Laid-Open Patent Publication No. H8-3870
PTL 4:
Japanese Laid-Open Patent Publication No. H9-291463
PTL 5:
Japanese Laid-Open Patent Publication No. 2005-9024
PTL 6:
Japanese Laid-Open Patent Publication No. 2006-132042
PTL 7:
WO 2019/054476

Summary of Invention

Technical Problem

[0014] For example, as disclosed in PTLs 5 to 7 and the like, infrared absorbing fibers containing infrared absorbing particles have been conventionally investigated. However, according to studies by the inventors of the present invention, in some cases, infrared absorbing particles such as tungsten oxide fine particles do not have sufficient chemical-resistant properties, and when infrared absorbing fibers and fiber products are exposed to chemical environments such as high-temperature acid or alkali, the infrared absorption properties may deteriorate.

[0015] It is an object of an aspect of the present invention to provide an infrared absorbing fiber having chemical-resistant properties.

Solution to Problem

[0016] According to one aspect of the present invention, an infrared absorbing fiber includes: a fiber; and organic-inorganic hybrid infrared absorbing particles, wherein the organic-inorganic hybrid infrared absorbing particles include infrared absorbing particles and a coating resin that covers at least a part of a surface of the infrared absorbing particles, and wherein the organic-inorganic hybrid infrared absorbing particles are located in one or more parts selected from an interior of the fiber and a surface of the fiber.

Advantageous Effects of Invention

[0017] According to one aspect of the present invention, an infrared absorbing fiber having chemical-resistant properties can be provided.

Brief Description of the Drawings

[0018]

[FIG. 1]
FIG. 1 is a schematic diagram of a crystal structure of a composite tungsten oxide having a hexagonal crystal; and
[FIG. 2]
FIG. 2 is a transmission electron micrograph of organic-inorganic hybrid infrared absorbing particles obtained in Example 1.

Description of Embodiments

[Infrared Absorbing Fiber]

[0019] In the present embodiment, a configuration example of an infrared absorbing fiber will be described.

[0020] The infrared absorbing fiber according to the present embodiment may include: a fiber; and organic-inorganic hybrid infrared absorbing particles.

[0021] The organic-inorganic hybrid infrared absorbing particles may include an infrared absorbing particles and a coating resin that covers at least a part of a surface of the infrared absorbing particles.

[0022] The organic-inorganic hybrid infrared absorbing particles may be located in the one or more parts selected from an interior of the fiber and a surface of the fiber.

[0023] As described above, in some cases, the infrared absorbing particles used in the infrared absorbing fiber do not have sufficient chemical-resistant properties. Therefore, the inventors of the present invention conducted an intensive study on a method for obtaining infrared absorbing particles having chemical-resistant properties. As a result, it was found that chemical-resistant properties can be exhibited by placing an organic material such as a resin directly on at least a part of the surface of the infrared absorbing particles to form organic-inorganic hybrid infrared absorbing particles.

[0024] However, the infrared absorbing particles are usually an inorganic material, and it has been difficult to place an organic material such as a resin on at least a part of the surface of the infrared absorbing particles. For this reason, organic-inorganic hybrid infrared absorbing particles and their production method were not known. Therefore, the inventors of the present invention conducted further studies and found the organic-inorganic hybrid infrared absorbing particles in which the organic material is located on the surface of the infrared absorbing particles and their production method.

[0025] By using the organic-inorganic hybrid infrared absorbing particles, it was found that the infrared absorbing fiber having chemical-resistant properties can be obtained, and the present invention was completed.

[0026] First, a method for producing the organic-inorganic hybrid infrared absorbing particles and the organic-inorganic hybrid infrared absorbing particles will be described.

1. Method for Producing Organic-Inorganic Hybrid Infrared Absorbing Particles

[0027] The infrared absorbing fiber according to the present embodiment may include the organic-inorganic hybrid infrared absorbing particles, as described above. The method for producing the organic-inorganic hybrid infrared absorbing particles may include, for example, the following steps.

[0028] A dispersion liquid preparation step for preparing a dispersion liquid including infrared absorbing particles, a dispersant, and a dispersion medium.

[0029] A dispersion medium reduction step for evaporating the dispersion medium from the dispersion liquid.

[0030] A raw material liquid mixture preparation step for preparing a raw material liquid mixture by mixing infrared absorbing particles collected after the dispersion medium reduction step, a raw material for a coating resin, an organic solvent, an emulsifier, water, and a polymerization initiator.

[0031] A stirring step in which the raw material liquid mixture is stirred while being cooled.

[0032] A polymerization step in which the raw material for the coating resin is polymerized after deoxygenation to reduce the oxygen amount in the raw material liquid mixture.

[0033] Each step will be described below.

(1) Dispersion Liquid Preparation Step

[0034] In the dispersion liquid preparation step, a dispersion liquid including infrared absorbing particles, a dispersant, and a dispersion medium, can be prepared.

[0035] Each material which can be suitably used in preparing the dispersion liquid in the dispersion liquid preparation step will be described below.

(a) Infrared absorbing particles

[0036] In the dispersion liquid preparation step, various infrared absorbing particles which are required to enhance chemical-resistant properties such as acid resistance and alkali resistance, for example, can be used as the infrared absorbing particles. As the infrared absorbing particles, for example, infrared absorbing particles including various materials containing free electrons may be preferably used, and infrared absorbing particles including various inorganic materials containing free electrons may be more preferably used.

[0037] As the infrared absorbing particles, it is particularly preferable to use infrared absorbing particles including one or more oxides selected from tungsten oxide having oxygen deficiency and composite tungsten oxide. When the tungsten oxide having oxygen deficiency and the composite tungsten oxide are used as the infrared absorbing particles, the organic-inorganic hybrid infrared absorbing particles including the infrared absorbing particles can be made light-colored to make them less noticeable. In this case, it is preferable that the infrared absorbing particles include, for example, one or more oxides selected from a tungsten oxide represented by a general formula W_yO_z (W: tungsten, O: oxygen, $2.2 \leq z/y \leq 2.999$) and a composite tungsten oxide represented by a general formula $M_xW_yO_z$ (an element M is one or more elements selected from among H, He, an alkali metal, an alkaline earth metal, a rare earth element, Mg, Zr, Cr, Mn, Fe, Ru, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Al, Ga, In, Tl, Si, Ge, Sn, Pb, Sb, B, F, P, S, Se, Br, Te, Ti, Nb, V, Mo, Ta, Re, Be, Hf, Os, Bi, and I, $0.001 \leq x/y \leq 1$, $2.0 \leq z/y \leq 3.0$).

[0038] It is known that materials containing free electrons typically exhibit a reflection absorption response to electromagnetic waves around the region of solar radiation with wavelengths from 200 nm to 2600 nm due to plasma oscillations. Therefore, various materials containing free electrons can be suitably used as the infrared absorbing particles. The infrared absorbing particles are preferable because, for example, when the particles are made smaller than the wavelength of light, geometric scattering in the visible light region (wavelength 380 nm to 780 nm) can be reduced, and particularly high transparency in the visible light region can be obtained.

[0039] As used herein, the term "transparency" means "highly transparent with little scattering for light in the visible light region".

[0040] Typically, because tungsten oxide (WO_3) does not have effective free electrons, it has little absorption/reflection properties in the infrared region, and thus it is not effective as an infrared absorbing particle.

[0041] In contrast, it is known that WO_3 with oxygen deficiency and the composite tungsten oxide in which positive elements such as Na and the like are added to WO_3 are conductive materials and are materials with free electrons. Analysis of the single crystal and the like of the materials with free electrons suggests that the free electrons respond to light in the infrared region.

[0042] According to studies by the inventors of the present invention, in a specific range of the composition of tungsten and oxygen, there is a range that is particularly effective as an infrared absorbing material, and tungsten oxides and composite tungsten oxides that are transparent in the visible light region and have particularly strong absorption in the infrared region can be formed.

[0043] The tungsten oxide or the composite tungsten oxide, which are a kind of materials of the infrared absorbing particles that can be suitably used in the dispersion liquid preparation step, will be further described below.

(a1) Tungsten Oxide

[0044] The tungsten oxide is represented by the general formula W_yO_z (where W is tungsten, O is oxygen, and $2.2 \leq z/y \leq 2.999$).

[0045] In the composition range of tungsten and oxygen in the tungsten oxide represented by the general formula W_yO_z, the composition ratio (z/y) of oxygen to tungsten is preferably less than 3, and more preferably $2.2 \leq z/y \leq 2.999$. In particular, the composition ratio is even more preferably $2.45 \leq z/y \leq 2.999$.

[0046] When the value of z/y is 2.2 or more, the infrared absorbing particles are particularly effective because appearance of an undesired WO_2 crystalline phase in the tungsten oxide can be avoided and chemical stability as a material can also be obtained.

[0047] In addition, by setting the value of z/y to preferably less than 3 and more preferably to 2.999 or less, a particularly sufficient amount of free electrons can be generated to enhance the absorption/reflection properties in the infrared region, resulting in forming efficient infrared absorbing particles.

[0048] In addition, what is known as "Magnelli phase", which has the composition ratio of $2.45 \leq z/y \leq 2.999$, is chemically stable and has excellent absorption properties in the near-infrared region, so that the tungsten oxide can be used more preferably as an infrared absorbing material. Therefore, the composition ratio z/y is even more preferably $2.45 \leq z/y \leq 2.999$, as described above.

(a2) Composite Tungsten Oxide

[0049] The composite tungsten oxide is obtained by adding the element M, which will be described later, to the WO_3 described above.

[0050] By adding the element M to form the composite tungsten oxide, free electrons are generated in WO_3, and strong absorption properties derived from free electrons appears especially in the near-infrared region. Such WO_3 becomes effective as near-infrared absorbing particles around 1,000 nm in wavelength.

[0051] In other words, when the WO_3 is made into the composite tungsten oxide by controlling the oxygen amount and adding the element M that generates free electrons, it can exhibit more efficient infrared absorption properties. When the WO_3 is made into the composite tungsten oxide by controlling the oxygen amount and adding the element M that generates free electrons, the general formula of the composite tungsten oxide is represented by $M_xW_yO_z$, the composition ratios preferably satisfy the relationship of $0.001 \leq x/y \leq 1$ and $2.0 \leq z/y \leq 3.0$. In the above general formula, M indicates the element M, W indicates tungsten, and O indicates oxygen.

[0052] When the value of x/y, which indicates the additive amount of the element M, is 0.001 or more as described above, a particularly sufficient amount of free electrons is generated in the composite tungsten oxide, and a high infrared absorption effect can be obtained. The higher the additive amount of the element M, the more free electrons are supplied, and the infrared absorption efficiency increases, but the effect is saturated when the value of x/y of about 1. When the value of x/y is 1 or less, it is preferable because the formation of impurity phases in the infrared absorbing particles containing the composite tungsten oxide can be avoided.

[0053] The element M is preferably one or more elements selected from among H, He, an alkali metal, an alkaline earth metal, a rare earth element, Mg, Zr, Cr, Mn, Fe, Ru, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Al, Ga, In, Tl, Si, Ge, Sn, Pb, Sb, B, F, P, S, Se, Br, Te, Ti, Nb, V, Mo, Ta, Re, Be, Hf, Os, Bi, and I.

[0054] In view of particularly enhancing stability in $M_xW_yO_z$, the element M is more preferably one or more elements selected from alkali metals, alkaline earth metals, rare earth elements, Mg, Zr, Cr, Mn, Fe, Ru, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Al, Ga, In, Tl, Si, Ge, Sn, Pb, Sb, B, F, P, S, Se, Br, Te, Ti, Nb, V, Mo, Ta, and Re. In view of improving the optical properties and weather resistance as infrared absorbing particles containing the composite tungsten oxide, the element M is even more preferably one or more elements selected from alkali metal elements, alkaline earth metal elements, transition metal elements, group 4B elements, and group 5B elements.

[0055] For the value of z/y, which indicates the additive oxygen amount, the same mechanism works in the composite tungsten oxide represented by $M_xW_yO_z$ as in the tungsten oxide represented by W_yO_z described above. In addition, the supply of free electrons due to the additive amount of the element M as described above also applies when the value of z/y is 3.0. Therefore, the ratio z/y is preferably $2.0 \leq z/y \leq 3.0$, more preferably $2.2 \leq z/y \leq 3.0$, and even more preferably $2.45 \leq z/y \leq 3.0$.

[0056] Further, when the composite tungsten oxide has a hexagonal crystal structure, the transmission of light in the visible light region of the infrared absorbing particles including the composite tungsten oxide is improved, and the absorption of light in the infrared region is improved. This will be explained with reference to FIG. 1, which is a schematic plan view of the hexagonal crystal structure.

[0057] FIG. 1 illustrates a projection view of the crystal structure of a composite tungsten oxide having a hexagonal structure when viewed in the (001) direction. The unit lattice 10 is indicated by the dotted line.

[0058] In FIG. 1, six octahedra 11 formed by WO_6 units are assembled to form a hexagonal void 12, and an element 121, which is an element M, is placed in the void 12 to form a single unit, and a large number of these single units are assembled to form a hexagonal crystal structure.

[0059] In order to improve the transmittance of light in the visible light region and to improve the absorption of light in the infrared region, the composite tungsten oxide may contain the unit structure described with reference to FIG. 1, and the composite tungsten oxide may be crystalline or amorphous.

[0060] When the cations of the element M are added and present in the hexagonal voids, the transmission of light in the visible light region is improved and the absorption of light in the infrared region is improved. Typically, the hexagonal crystal is easily formed when an element M having a large ionic radius is added. Specifically, when one or more elements selected from Cs, K, Rb, Tl, In, Ba, Li, Ca, Sr, Fe, and Sn are added as the element M, hexagonal crystals are easily formed. Elements other than these elements can also be used, as long as the above-mentioned element M is present in the hexagonal voids formed by WO_6 units, and are not limited to the above-mentioned elements.

[0061] The composite tungsten oxide having a hexagonal crystal structure has a uniform crystal structure. The additive amount of the element M is preferably 0.2 or more and 0.5 or less in terms of the value of x/y in the general formula described above, and is more preferably 0.33. When the value of x/y is 0.33, the element M is considered to be placed in all of the hexagonal voids.

[0062] Alternatively, other than the infrared absorbing particles including composite tungsten oxide with hexagonal crystal structure, infrared absorbing particles including composite tungsten oxides with tetragonal crystal structure and cubic crystal structure also exert sufficiently effective infrared absorption properties. Depending on the crystal structure, the absorption position in the infrared region tends to change. In the order of cubic<tetragonal<hexagonal, the absorption position tends to move to the long wavelength side. Associated with the above, less absorption of light in the visible light region is the order of hexagonal, tetragonal and cubic. Therefore, for applications that transmit more light in the visible light region and shield more light in the infrared region, hexagonal composite tungsten oxide is preferably used. The tendency in optical properties described here is only a general tendency. The tendency of optical properties varies depending on the type of element added, the amount added, and the oxygen amount. The present invention is not limited to these.

[0063] The infrared absorbing particles containing tungsten oxides or composite tungsten oxides greatly absorb light in the near infrared region, especially around the wavelength of 1,000 nm. Therefore, many of the transmissive color tones are of a blue to green color tone.

[0064] The dispersed particle size of the infrared absorbing particles can be selected according to their intended use.

[0065] First, the infrared absorbing particles with 800 nm or less in the dispersed particle size are preferably used when the particles are used while maintaining the transparency. This is because particles having a dispersed particle size of 800 nm or less do not completely block light due to scattering, and can retain visibility in the visible light region, while maintaining transparency efficiently at the same time. When transparency in the visible light region is particularly important, it is preferable to further consider the reduction of scattering by particles.

[0066] When the reduction of scattering by particles is important, the dispersed particle size is preferably 200 nm or less, and more preferably 100 nm or less. This is because, when the dispersed particle size is small, scattering of light in the visible light region having a wavelength of 400 nm or more and 780 nm or less due to geometric scattering or Mie scattering is reduced. As a result, for example, an infrared absorbing film having dispersed infrared absorbing particles becomes like frosted glass, and clear transparency cannot be obtained. In other words, when the dispersed particle size is 200 nm or less, the geometric scattering or Mie scattering is reduced and the Rayleigh scattering region is reached. In the Rayleigh scattering region, the scattered light is reduced in proportion to the sixth power of the particle size, so the scattering is reduced as the dispersed particle size is reduced, and transparency is improved.

[0067] Furthermore, when the dispersed particle size is 100 nm or less, the scattered light becomes very small, which is desirable. From the viewpoint of avoiding light scattering, the smaller the dispersed particle size, the more desirable it is.

[0068] The lower limit of the dispersed particle size of the infrared absorbing particles is not limited, but the dispersed particle size is preferably 1 nm or more, for example, because such particle size is easily manufactured industrially.

[0069] When the dispersed particle size of the infrared absorbing particles is set to 800 nm or less, the haze value of the dispersed infrared absorbing particles in the medium can be set to 30% or less with a visible light transmittance of 85% or less. When the haze is set to 30% or less, it is possible to prevent the infrared absorbing particle dispersion from becoming like cloudy glass to obtain particularly clear transparency.

[0070] The dispersed particle size of the infrared absorbing particles can be measured using ELS-8000 manufactured by Otsuka Electronics Co., Ltd. or other instruments based on the principle of dynamic light scattering.

[0071] From the viewpoint of demonstrating excellent infrared absorption properties, the crystallite size of the infrared absorbing particles is preferably 1 nm or more and 200 nm or less, more preferably 1 nm or more and 100 nm or less, and even more preferably 10 nm or more and 70 nm or less. The crystallite size can be measured by measuring the X-ray diffraction pattern using a powder X-ray diffraction method (Θ-2Θ method) and analysis using Rietveld method. The X-ray diffraction pattern can be measured using, for example, a powder X-ray diffractometer "X'Pert-PRO/MPD" manufactured by PANalytical, Spectris Co., Ltd.

(b) Dispersant

[0072] The dispersant is used to treat the surface of the infrared absorbing particles to make the surface of the infrared absorbing particles hydrophobic. The dispersant can be selected according to the dispersion system, which is a combination of the infrared absorbing particles, the dispersion medium, the raw material for the coating resin, and the like. Among them, dispersants having one or more functional groups selected from amino group, hydroxyl group, carboxyl group, sulfo group, phosphate group, and epoxy group can be suitably used. When the infrared absorbing particles are tungsten oxides or composite tungsten oxides, the dispersant more preferably has amino group as the functional group.

[0073] The dispersant more preferably has amino group as the functional group as described above, that is, the dispersant is preferably an amine compound. The amine compound is more preferably a tertiary amine.

[0074] The dispersant is preferably a polymeric material because the dispersant is used for the purpose of hydrophobizing the surface of the infrared absorbing particles. For this reason, a dispersant having one or more types selected from long-chain alkyl groups and benzene rings is preferably used, for example. As the dispersant, a polymer dispersant or the like having a copolymer of styrene and a tertiary amine 2-(dimethylamino) ethyl methacrylate in the side chain, can be more preferably used. This polymer dispersant can also be used as a raw material for a coating resin. The long-chain alkyl group preferably has 8 or more carbon atoms. For example, the dispersant that is the polymeric material and is the amine compound may be used.

[0075] The additive amount of the dispersant is not particularly limited, and can be freely selected. The suitable amount of the dispersant can be selected according to the type of the dispersant, the type of the infrared absorbing particles, the specific surface area of the infrared absorbing particles, and the like. For example, it is preferable that the amount of the dispersant added is 10 parts by mass or more and 500 parts by mass or less with respect to 100 parts by mass of the infrared absorbing particles, because it is particularly easy to prepare a dispersion liquid with a favorable dispersion state. The additive amount of the dispersant is more preferably 10 parts by mass or more and 100 parts by mass or less, and even more preferably 20 parts by mass or more and 50 parts by mass or less.

(c) Dispersion Medium

[0076] The dispersion medium may be any dispersion media that can disperse the infrared absorbing particles and dispersants to prepare a dispersion liquid. For example, various organic compounds may be used.

[0077] As the dispersion medium, for example, one or more selected from aromatic hydrocarbons such as toluene and xylene can be suitably used.

[0078] In the dispersion liquid preparation step, the dispersion liquid may be prepared by mixing the infrared absorbing particles, the dispersant, and the dispersion medium. It is preferable to pulverize the infrared absorbing particles at the time of mixing in order to reduce the dispersed particle size of the infrared absorbing particles and to disperse them uniformly in the dispersion liquid.

[0079] The mixing means used for mixing and pulverizing the infrared absorbing particles, the dispersant, and the dispersion medium are not particularly limited, but one or more types selected from, for example, a bead mill, a ball mill, a sand mill, a paint shaker, an ultrasonic homogenizer, and the like may be used. In particular, as the mixing means, media stirring mills such as a bead mill, a ball mill, a sand mill, a paint shaker, and the like that use media such as beads, balls, and Ottawa sand are more preferably used. This is because, by using the media stirring mills, it is possible to achieve a desired dispersed particle size for the infrared absorbing particles, especially in a short time, and it is preferable from the viewpoint of productivity and control of impurities.

(2) Dispersion Medium Reduction Step

[0080] In the dispersion medium reduction step, the dispersion medium can be evaporated from the dispersion liquid and dried.

[0081] In the dispersion medium reduction step, it is preferable that the dispersion medium is sufficiently evaporated from the dispersion liquid to recover the infrared absorbing particles.

[0082] The specific means of evaporating the dispersion medium are not particularly limited, but for example, a dryer such as an oven, a vacuum fluid dryer such as an evaporator or a vacuum grinder, a spray dryer such as a spray drying device, and the like may be used.

[0083] The degree to which the dispersion medium is evaporated is also not particularly limited, but it is preferable that the percentage of the dispersion medium can be sufficiently reduced so that powdered infrared absorbing particles can be obtained after the dispersion medium reduction step, for example.

[0084] By evaporating the dispersion medium, it is possible to obtain the infrared absorbing particles in which the dispersant is placed around the infrared absorbing particles and the surface is hydrophobized. Therefore, it is possible to enhance the adhesion between the hydrophobized infrared absorbing particles and the coating resin in which the raw material for the coating resin is polymerized. Thus, it is possible to place the coating resin on at least a part of the surface of the infrared absorbing particles by the polymerization step described later and the like.

(3) Raw Material Liquid Mixture Preparation Step

[0085] In the raw material liquid mixture preparation step, the infrared absorbing particles collected after the dispersion medium reduction step, the raw material for the resin coating, the organic solvent, the emulsifier, water, and the polymerization initiator are mixed to prepare the raw material liquid mixture.

[0086] The infrared absorbing particles collected after the dispersion medium reduction step may be infrared absorbing particles containing the dispersant, due to the attachment of the dispersant supplied in the dispersion liquid preparation step to the surface of the particles. Therefore, when the dispersant is attached to the infrared absorbing particles, the infrared absorbing particles containing the dispersant collected after the dispersion medium reduction step are used as the infrared absorbing particles, in the raw material liquid mixture preparation step.

[0087] Hereinafter, each material other than the infrared absorbing particles used in the raw material liquid mixture preparation step will be described.

(a) Raw Material for Coating Resin

[0088] The raw material for the coating resin is polymerized in the polymerization step described later, and becomes the coating resin that is placed on at least a part of the surface of the infrared absorbing particles. Therefore, as the raw material for the coating resin, various monomers or the like that can form the desired coating resin by polymerization can be selected.

[0089] The coating resin after polymerization is not particularly limited, but for example, one or more types of resins selected from a thermoplastic resin, a thermosetting resin, a photocurable resin, or the like can be used.

[0090] Examples of the thermoplastic resin include polyester resin, polycarbonate resin, acrylic resin, polystyrene resin, polyamide resin, vinyl chloride resin, olefin resin, fluorine resin, polyvinyl acetate resin, thermoplastic polyurethane resin, acrylonitrile butadiene styrene resin, polyvinyl acetal resin, acrylonitrile-styrene copolymer resin, ethylene-vinyl acetate copolymer resin, and the like.

[0091] Examples of the thermosetting resin include phenol resin, epoxy resin, melamine resin, urea resin, unsaturated polyester resin, alkyd resin, thermosetting polyurethane resin, polyimide resin, silicone resin, and the like.

[0092] Examples of the photocurable resin include a resin to be cured by irradiation of any one of ultraviolet, visible, or near-infrared light.

[0093] In particular, the coating resin preferably contains one or more types of resins selected from polyester resin, polycarbonate resin, acrylic resin, polystyrene resin, polyamide resin, vinyl chloride resin, olefin resin, fluorine resin, polyvinyl acetate resin, polyurethane resin, acrylonitrile butadiene styrene resin, polyvinyl acetal resin, acrylonitrile-styrene copolymer resin, ethylene-vinyl acetate copolymer resin, phenol resin, epoxy resin, melamine resin, urea resin, unsaturated polyester resin, alkyd resin, polyimide resin, and silicone resin. As the polyurethane resin, both thermoplastic polyurethane and thermosetting polyurethane may be used.

[0094] As the coating resin, a photocurable resin may also be suitably used. As the photocurable resin, a resin to be cured by irradiation of any one of ultraviolet, visible, or infrared light may be suitably used, as described above.

[0095] Among them, it is preferable that the coating resin is a resin to which a mini-emulsion polymerization method can be applied, and it is more preferable that the coating resin contains a polystyrene resin, for example. When the coating resin is polystyrene, styrene can be used as the raw material for the coating resin.

[0096] As a crosslinking agent, a multi-functional vinyl monomer such as divinylbenzene, ethylene glycol dimethacrylate, or the like may also be added.

(b) Organic Solvent

[0097] The organic solvent is not particularly limited, but any water-insoluble solvent may be used. Among them, an organic solvent having a low molecular weight is preferable. Examples of the organic solvent include one or more types selected from long-chain alkyl compounds such as hexadecane and the like; alkyl esters of methacrylic acid having a long-chain alkyl moiety such as dodecyl methacrylate, stearyl methacrylate, and the like; higher alcohols such as cetyl alcohol and the like; oils such as olive oil and the like; and the like.

[0098] As the organic solvent, particularly, the long-chain alkyl compounds are more preferable, and hexadecane is even more preferable.

(c) Emulsifier

[0099] The emulsifier, that is, a surfactant, may be cationic, anionic, nonionic, and the like, and is not particularly limited.

[0100] Examples of the cationic emulsifier include alkylamine salts, quaternary ammonium salts, and the like.

[0101] Examples of the anionic emulsifier include acid salts, ester salts, and the like.

[0102] Examples of the nonionic emulsifier include various esters, various ethers, various ester ethers, alkanolamides, and the like.

[0103] As the emulsifier, for example, one or more types selected from the materials as described above may be used.

[0104] Among them, a cationic emulsifier, that is a surfactant that exhibits cationic properties, is preferably used from the viewpoint that the infrared absorbing particles particularly easily form organic-inorganic hybrid infrared absorbing particles.

[0105] In particular, when the amine compound is used as the dispersant, the emulsifier is preferably one or more cationic emulsifiers selected from dodecyltrimethylammonium chloride (DTAC), cetyltrimethylammonium chloride (CTAC), and the like.

[0106] When the amine compound is used as the dispersant, it may be difficult to form the organic-inorganic hybrid infrared absorbing particles when sodium dodecyl sulfate (SDS), which is an anionic emulsifier, is used. When preparing the raw material liquid mixture, the emulsifier can be added as an aqueous solution, for example, by simultaneously adding the emulsifier with water. In this case, the emulsifier is preferably added as an aqueous solution adjusted to a concentration of 1 time or higher and 10 times or lower of the critical micelle concentration (CMC) .

(d) Polymerization Initiator

[0107] The polymerization initiator is not particularly limited, but one or more types selected from various polymerization initiators such as radical polymerization initiators, ionic polymerization initiators, and the like may be used.

[0108] Examples of the radical polymerization initiator include azo compounds, dihalogen, organic peroxides, and the like. Examples also include a redox initiator that combines an oxidizing agent and a reducing agent, such as hydrogen peroxide and an iron (II) salt, persulfate and sodium bisulfite, and the like.

[0109] Examples of the ionic polymerization initiator include nucleophiles such as n-butyl lithium, an electrophilic agent such as a protonic acid, a Lewis acid, a halogen molecule, and a carbocation, and the like.

[0110] As the polymerization initiator, for example, one or more types selected from 2,2'-azobisisobutyronitrile (AIBN), potassium peroxodisulfate (KPS), 2,2'-azobis(2-methylpropionamidine) dihydrochloride (V-50), 2,2'-azobis(2-methyl-N-(2-hydroxyethyl) propionamidine) (VA-086), and the like may be suitably used.

[0111] When preparing the raw material liquid mixture, the polymerization initiator can be added to the organic phase or the aqueous phase, depending on the type. For example, when 2,2'-azobisisobutyronitrile (AIBN) is used, AIBN can be added to the organic phase. When potassium peroxodisulfate (KPS) or 2,2'-azobis(2-methylpropionamidine) dihydrochloride (V-50) is used, KPS or V-50 can be added to the aqueous phase.

[0112] In the raw material liquid mixture preparation step, it is sufficient to prepare the raw material liquid mixture by mixing the infrared absorbing particles collected after the dispersion medium reduction step, the raw material for the coating resin, the organic solvent, the emulsifier, water, and the polymerization initiator. Accordingly, the preparation procedure and the like of the raw material liquid mixture is not particularly limited, but for example, as the aqueous phase, a liquid mixture containing the emulsifier can be prepared in advance. In addition, as the organic phase, a liquid mixture can be prepared in which the raw material for the coating resin and the infrared absorbing particles collected after the dispersion medium reduction step are dispersed in the organic solvent.

[0113] The polymerization initiator may be added to the aqueous phase or to the organic phase, according to the type of the polymerization initiator used as described above.

[0114] The raw material liquid mixture may be prepared by adding and mixing the organic phase to the aqueous phase.

[0115] It is preferable to add the organic phase to the aqueous phase and stir it sufficiently so that the coating resin can be evenly arranged on the surface of the infrared absorbing particles. In other words, it is preferable that the raw material liquid mixture preparation step further includes a stirring step of stirring the obtained liquid mixture in addition to the mixing step of mixing the infrared absorbing particles collected after the dispersion medium reduction step, the raw material for the coating resin, the organic solvent, the emulsifier, water, and the polymerization initiator.

[0116] In the stirring step, stirring may be performed using a stirrer, for example. When the stirring step is carried out, the degree of stirring is not particularly limited, but for example, it is preferable to carry out the stirring so that an oil-in-water in which the infrared absorbing particles encapsulated in the raw material for the coating resin are dispersed in the aqueous phase, are formed.

[0117] The additive amount of the polymerization initiator is not particularly limited and may be freely selected. The additive amount of the polymerization initiator may be selected according to the type of the raw material for the coating resin, the type of the polymerization initiator, the size of the oil droplets that are mini-emulsions, the ratio of the raw material for the coating resin to the infrared absorbing particles, and the like. For example, when the additive amount of the polymerization initiator is 0.01 mol% or more and 1,000 mol% or less with respect to the raw material for the coating resin, it is preferable because it is easy to obtain the organic-inorganic hybrid infrared absorbing particles in which the infrared absorbing particles are sufficiently covered with the coating resin. The additive amount of the polymerization initiator is more preferably 0.1 mol% or more and 200 mol% or less with respect to the raw material for the coating resin, and even more preferably 0.2 mol% or more and 100 mol% or less.

(4) Stirring Step

[0118] In the stirring step, the raw material liquid mixture obtained in the raw material liquid mixture preparation step may be stirred while being cooled.

[0119] The degree of the stirring in the stirring step is not particularly limited and may be freely selected. For example, it is preferable to perform the stirring so that the oil-in-water, which is an O/W type emulsion in which the infrared absorbing particles encapsulated in the raw material for the coating resin are dispersed in the aqueous phase, becomes mini-emulsions having the size, or diameter, of 50 nm or more and 500 nm or less.

[0120] The mini-emulsion is obtained by adding a substance that is almost insoluble in water, that is, a hydrophobe, to the organic phase and applying a strong shear force thereto. Examples of the hydrophobe include the organic solvent described above in the raw material liquid mixture preparation step. Further, as a method of applying the strong shear force, for example, ultrasonic vibration is applied to the raw material liquid mixture by a homogenizer or the like.

[0121] In the stirring step, the stirring is preferably performed while cooling the raw material liquid mixture as described above. This is because by cooling the raw material liquid mixture, a mini-emulsion can be formed while minimizing the progress of the polymerization reaction.

[0122] The degree of cooling of the raw material liquid mixture is not particularly limited, but it is preferable to cool the raw material liquid mixture by using a refrigerant of 0°C or lower, for example, by means of an ice bath or the like.

(5) Polymerization Step

[0123] In the polymerization step, the polymerization reaction of the raw material for the coating resin may be carried out after deoxygenation to reduce the oxygen amount in the raw material liquid mixture.

[0124] In the polymerization step, the raw material for the coating resin may be polymerized, and the coating resin may be placed on at least a part of the surface of the infrared absorbing particles.

[0125] The conditions in the polymerization step are not particularly limited. The deoxygenation to reduce the oxygen amount in the raw material liquid mixture may be carried out before starting the polymerization. Specific methods of the deoxygenation are not particularly limited, but include a method for performing ultrasonic irradiation and a method for blowing an inert gas into the raw material liquid mixture.

[0126] The specific conditions for carrying out the polymerization reaction may be freely selected according to the raw material for the coating resin or the like added to the raw material liquid mixture. The polymerization reaction may be carried out by, for example, heating the raw material liquid mixture or irradiating the raw material liquid mixture with light of a predetermined wavelength.

[0127] According to the method for producing the organic-inorganic hybrid infrared absorbing particles according to the present embodiment described above, the organic-inorganic hybrid infrared absorbing particles can be obtained by placing an organic material such as a resin on at least a part of the surface of the infrared absorbing particles, which has been difficult in the conventional technique. Accordingly, even when exposed to an environment of chemicals such as acids or alkalis at high temperatures, the infrared absorbing particles can be prevented from coming into direct contact with the chemical components such as acids or alkalis. Therefore, the infrared absorbing particles have excellent chemical resistance properties and it is possible to minimize the deterioration of the infrared absorption properties.

2. Organic-Inorganic Hybrid Infrared Absorbing Particles

[0128] The organic-inorganic hybrid infrared absorbing particles according to the present embodiment, which can be suitably used in the infrared absorbing fiber, will be described. The organic-inorganic hybrid infrared absorbing particles may include infrared absorbing particles and a coating resin that covers at least a part of a surface of the infrared absorbing particles. The organic-inorganic hybrid infrared absorbing particles may be produced, for example, by the method for producing the organic-inorganic hybrid infrared absorbing particles described above. For this reason, explanations of some of the matters already explained will be omitted.

[0129] As described above, the coating resin is placed on the surface of the infrared absorbing particle and the coating resin covers at least a part of the surface of the infrared absorbing particles, which has been difficult in the conventional technique. Accordingly, even when exposed to an environment of chemicals such as acids or alkalis at high temperatures, the infrared absorbing particle can be prevented from coming into direct contact with the chemical components such as acids or alkalis. Therefore, the infrared absorbing fiber according to the present embodiment, which includes the organic-inorganic hybrid infrared absorbing particles, has excellent chemical resistance properties and it is possible to minimize the deterioration of the infrared absorption properties.

[0130] Because the infrared absorbing particles are already explained in the method for producing the organic-inorganic hybrid infrared absorbing particles, the explanations will be omitted. For example, infrared absorbing particles including various materials containing free electrons may be preferably used, and infrared absorbing particles including various inorganic materials containing free electrons may be more preferably used.

[0131] As the infrared absorbing particles, it is particularly preferable to use infrared absorbing particles including one or more oxides selected from tungsten oxide having oxygen deficiency and composite tungsten oxide. In this case, it is preferable that the infrared absorbing particles include, for example, one or more oxides selected from tungsten oxide represented by a general formula W_yO_z (W: tungsten, O: oxygen, $2.2 \leq z/y \leq 2.999$) and a composite tungsten oxide represented by a general formula $M_xW_yO_z$ (an element M is one or more elements selected from among H, He, an alkali metal, an alkaline earth metal, a rare earth element, Mg, Zr, Cr, Mn, Fe, Ru, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Al, Ga, In, Tl, Si, Ge, Sn, Pb, Sb, B, F, P, S, Se, Br, Te, Ti, Nb, V, Mo, Ta, Re, Be, Hf, Os, Bi, and I, $0.001 \leq x/y \leq 1$, $2.0 \leq z/y \leq 3.0$).

[0132] Because the coating resin is also already explained in the method for producing the organic-inorganic hybrid infrared absorbing particles, the explanations will be omitted. For example, one or more types of resins selected from a thermoplastic resin, a thermosetting resin, a photocurable resin, or the like can be used. In particular, the coating resin preferably contains one or more types of resins selected from polyester resin, polycarbonate resin, acrylic resin, polystyrene resin, polyamide resin, vinyl chloride resin, olefin resin, fluorine resin, polyvinyl acetate resin, polyurethane resin, acrylonitrile butadiene styrene resin, polyvinyl acetal resin, acrylonitrile-styrene copolymer resin, ethylene-vinyl acetate copolymer resin, phenol resin, epoxy resin, melamine resin, urea resin, unsaturated polyester resin, alkyd resin, polyimide resin, and silicone resin. As the polyurethane resin, both thermoplastic polyurethane and thermosetting polyurethane may be used.

[0133] As the coating resin, a photocurable resin may also be suitably used. As the photocurable resin, a resin to be cured by irradiation of any one of ultraviolet, visible, or infrared light may be suitably used, as described above.

[0134] Among them, it is preferable that the coating resin is a resin to which a mini-emulsion polymerization method can be applied, and it is more preferable that the coating resin contains a polystyrene resin, for example.

[0135] In the organic-inorganic hybrid infrared absorbing particles described above, the coating resin, which is an organic material, is placed on at least a part of the surface of the infrared absorbing particles, which has been difficult in the conventional technique. Accordingly, even when exposed to an environment of chemicals such as acids or alkalis at high temperatures, the infrared absorbing particles can be prevented from coming into direct contact with the chemical components such as acids or alkalis. Therefore, the organic-inorganic hybrid infrared absorbing particles has excellent chemical resistance properties and it is possible to minimize the deterioration of the infrared absorption properties. The infrared absorbing fiber using the organic-inorganic hybrid infrared absorbing particles can also has chemical resistance properties.

[0136] The infrared absorbing fiber according to the present embodiment may include fibers in addition to the organic-inorganic hybrid infrared absorbing particles described so far.

[0137] The infrared absorbing fiber according to the present embodiment can be produced by dispersing the organic-inorganic hybrid infrared absorbing particles described above in a suitable medium and by including the dispersion in one or more parts selected from the interior of the fiber and the surface of the fiber. The fiber and the like will be explained below.

3. Fiber

[0138] The fiber included in the infrared absorbing fiber according to the present embodiment may be selected from various types of fiber according to the application.

[0139] The fiber included in the infrared absorbing fiber according to the present embodiment may include one or more fibers selected from a synthetic fiber, a semisynthetic fiber, a natural fiber, a reclaimed fiber, and an inorganic fiber, for example. Specifically, for example, any one or more of the following fibers may be used as the fiber: one or more fibers selected from a synthetic fiber, a semisynthetic fiber, a natural fiber, a reclaimed fiber, and an inorganic fiber; or one or more fibers selected from mixed yarns such as a blended yarn, a doubled yarn, or a combined filament yarn using one or more fibers selected from the above fiber groups; and the like. In consideration of incorporating the organic-inorganic hybrid infrared absorbing particles into the fibers by a simple method and maintaining heat retention, preferably the fibers include synthetic fibers, and more preferably the fibers are synthetic fibers.

[0140] When the infrared absorbing fiber according to the present embodiment includes the synthetic fiber as the fiber, the specific type of the synthetic fiber is not particularly limited. For example, one or more fibers selected from a polyurethane fiber, a polyamide fiber, an acrylic fiber, a polyester fiber, a polyolefin fiber, a polyvinyl alcohol fiber, a polyvinylidene chloride fiber, a polyvinyl chloride fiber, a polyether ester fiber, and the like, may be suitably used.

[0141] Examples of the polyamide fiber include one or more fibers selected from nylon, nylon 6, nylon 66, nylon 11, nylon 610, nylon 612, aromatic nylon, aramid, and the like.

[0142] Examples of the acrylic fiber include one or more fibers selected from polyacrylonitrile, acrylonitrile-vinyl chloride copolymer, modacrylic fiber, and the like.

[0143] Examples of the polyester fiber include one or more fibers selected from polyethylene terephthalate, polybutylene terephthalate, polytrimethylene terephthalate, polyethylene naphthalate, and the like.

[0144] Examples of the polyolefin fiber include one or more fibers selected from polyethylene, polypropylene, polystyrene, and the like.

[0145] Examples of the polyvinyl alcohol fiber include vinylon and the like.

[0146] Examples of the polyvinylidene chloride fiber include vinylidene and the like.

[0147] Examples of the polyvinyl chloride fiber include polyvinyl chloride and the like.

[0148] Examples of the polyether ester fiber include one or more fibers selected from Rexe, Success and the like.

[0149] When the infrared absorbing fiber according to the present embodiment includes the semisynthetic fiber as the fiber, the semisynthetic fiber preferably includes one or more fibers selected from, for example, a cellulose fiber, a protein fiber, chlorinated rubber, hydrochlorinated rubber, and the like.

[0150] Examples of the cellulose fiber include one or more fibers selected from acetate, triacetate, acetate oxide, and the like.

[0151] Examples of the protein fiber include Promix and the like.

[0152] When the infrared absorbing fiber according to the present embodiment includes the natural fiber as the fiber, the natural fiber preferably includes one or more fibers selected from, for example, a vegetable fiber, an animal fiber, a mineral fiber, and the like.

[0153] Examples of the vegetable fiber include one or more fibers selected from cotton, ceiba, flax, hemp, jute, manila hemp, sisal hemp, New Zealand flax, luobuma, palm fibers, rush, straw, and the like.

[0154] Examples of the animal fiber include one or more fibers selected from wool, goat hair, mohair, cashmere, alpaca, angora, camel, vicuna, and other wools; and silk, down, feathers, and the like.

[0155] Examples of the mineral fiber include one or more fibers selected from asbestos and the like.

[0156] When the infrared absorbing fiber according to the present embodiment includes the reclaimed fiber as the fiber, the reclaimed fiber preferably includes one or more fibers selected from, for example, a cellulose fiber, a protein fiber, an algin fiber, a rubber fiber, a chitin fiber, a mannan fiber, and the like.

[0157] Examples of the cellulose fiber include one or more fibers selected from rayon, viscous rayon, cupra, polynosic fiber, cuprammonium rayon, and the like.

[0158] Examples of the protein fiber include one or more fibers selected from a casein fiber, a peanut protein fiber, a maize protein fiber, a soy protein fiber, a reclaimed silk, and the like.

[0159] When the infrared absorbing fiber according to the present embodiment includes the inorganic fiber as the fiber, the inorganic fiber preferably includes one or more fibers selected from, for example, a metal fiber, a carbon fiber, a silicate fiber, and the like.

[0160] Examples of the metal fiber include one or more fibers selected from a metal fiber, a gold thread, a silver thread, a heat resistant alloy fiber, and the like.

[0161] Examples of the silicate fiber include one or more fibers selected from a glass fiber, a slag fiber, a rock fiber, and the like.

[0162] The cross sectional shape of the fiber of the infrared absorbing fiber according to the present embodiment is not particularly limited. Examples of the cross sectional shape include one or more shapes selected from a circular shape, a triangular shape, a hollow shape, a flat shape, a Y-shape, a star shape, a core-sheath shape, and the like. The infrared absorbing fiber according to the present embodiment may include fibers with different cross sectional shapes at the same time.

[0163] The organic-inorganic hybrid infrared absorbing particles may be located in one or more parts selected from the interior of the fiber and the surface of the fiber in various ways depending on the cross sectional shape of the fiber and the like. For example, in the case where the cross sectional shape of the fiber is the core-sheath type, the organic-inorganic hybrid infrared absorbing particles may be included in the core portion or in the sheath portion of the fiber. The shape of the fiber included in the infrared absorbing fiber according to the present embodiment may be a filament (long fiber) or a staple (short fiber).

4. Additive

[0164] The infrared absorbing fiber according to the present embodiment may include an antioxidant, a flame retardant, a deodorant, an insect repellent, an antibacterial agent, an ultraviolet absorber, and the like, depending on the purpose, within a range that does not impair the performance of the fiber included.

[0165] In addition to the infrared absorbing material, the infrared absorbing fiber according to the present embodiment may further contain particles having a far-infrared radiation ability. The particles having the far-infrared radiation ability may be located in one or more parts selected from, for example, the interior of the fiber and the surface of the fiber. As the particles having the far-infrared radiation ability, one or more compounds selected from, for example, metal oxides such as ZrO_2, SiO_2, TiO_2, Al_2O_3, MnO_2, MgO, Fe_2O_3, CuO, and the like; carbides such as ZrC, SiC, TiC, and the like; nitrides such as ZrN, Si_3N_4, AlN, and the like; and the like may be suitably used.

[0166] The organic-inorganic hybrid infrared absorbing particles included in the infrared absorbing fiber according to the present embodiment are an infrared absorbing material and are a near infrared absorbing material. The organic-inorganic hybrid infrared absorbing particles according to the present embodiment have a property of absorbing solar light energy having a wavelength of 0.3 um or more and 3 pm or less. In particular, the organic-inorganic hybrid infrared absorbing particles according to the present embodiment selectively absorbs the near infrared region having a wavelength of 0.9 um or more and 2.2 um or less, and converts it into heat, or re-radiates it.

[0167] In contrast, the particles having the far-infrared radiation ability described above has an ability of receiving the energy absorbed by the organic-inorganic hybrid infrared absorbing particles, which are a near infrared absorbing material, and converting the energy into heat energy of mid/far infrared wavelengths and radiating the heat energy. For example, the particles of ZrO_2 convert the energy into heat energy having a wavelength of 2 um or more and 20 um or less, and radiate the heat energy. Accordingly, the particles having the far-infrared radiation ability and the organic-inorganic hybrid infrared absorbing particles are present in the interior and on the surface of the fiber together, so that the solar energy absorbed by the organic-inorganic hybrid infrared absorbing particles can be efficiently consumed in the interior and on the surface of the fiber, and heat is retained more effectively, for example.

[0168] In the infrared absorbing fiber according to the present embodiment, as described above, the organic-inorganic hybrid infrared absorbing particles may be located in one or more parts selected from the interior of the fiber and the surface of the fiber. That is, the organic-inorganic hybrid infrared absorbing particles may be located in both the interior of the fiber and the surface of the fiber, or in either the interior of the fiber or the surface of the fiber.

[0169] Because the organic-inorganic hybrid infrared absorbing particles have excellent chemical resistance as described above, the infrared absorbing fiber according to the present embodiment including the organic-inorganic hybrid infrared absorbing particles can also have excellent chemical resistance.

[Method for Producing Infrared Absorbing Fiber]

[0170] The method for producing the infrared absorbing fiber according to the present embodiment is not particularly limited. The infrared absorbing fiber may be produced by placing the organic-inorganic hybrid infrared absorbing particles on one or more parts selected from the surface of the fiber and the interior of the fiber.

[0171] For example, the infrared absorbing fiber according to the present embodiment may be produced by the following production method (a) to (d).

[0172]

(a) A method whereby the organic-inorganic hybrid infrared absorbing particles are directly mixed and spun with the starting material polymer of a synthetic fiber.

(b) A method whereby a master batch is manufactured in advance in which the organic-inorganic hybrid infrared absorbing particles are added in a large concentration to a portion of the starting material polymer, and spinning is performed after the master batch is diluted to a prescribed concentration.

(c) A method whereby the organic-inorganic hybrid infrared absorbing particles are uniformly dispersed in advance in the starting material monomer or oligomer solution, and the dispersion liquid is used to synthesize the desired starting material polymer while the organic-inorganic hybrid infrared absorbing particles are simultaneously dispersed in the starting material polymer, after which spinning is performed.

(d) A method whereby a binding agent or the like is used to attach the organic-inorganic hybrid infrared absorbing particles to the surfaces of fibers obtained by spinning in advance.

[0173] The production method (a) to (d) described above, wherein the fiber included in the infrared absorbing fiber according to the present embodiment includes the organic-inorganic hybrid infrared absorbing particles, will be described with specific examples.

Method (a):

[0174] For example, a case where polyester fiber is used as the fiber will be described.

[0175] An organic-inorganic hybrid infrared absorbing particles dispersion liquid is added to a pellet of polyethylene terephthalate resin, which is a thermoplastic resin, and mixed uniformly with a blender, and then the solvent is removed. The mixture in which the solvent is removed is melt-kneaded with a twin-screw extruder to obtain a master batch containing the organic-inorganic hybrid infrared absorbing particles. The master batch containing the organic-inorganic hybrid infrared absorbing particles is melt-mixed near the melting temperature of the resin and spun according to various known methods, for example.

[0176] A dispersant may be added to improve the dispersibility of the organic-inorganic hybrid infrared absorbing particles to the polyethylene terephthalate resin. The dispersant is not limited as long as it can disperse the organic-inorganic hybrid infrared absorbing particles into the polyethylene terephthalate resin or into a fiber obtained by spinning the master batch containing the resin. For example, the dispersant applied to the polyethylene terephthalate resin is not particularly limited, but is preferably, for example, a polymer dispersant, and is more preferably a dispersant having a main chain selected from polyester, polyether, polyacrylic, polyurethane, polyamine, polystyrene, and aliphatic, or having a main chain copolymerized with two or more types of unit structures selected from polyester, polyether, polyacrylic, polyurethane, polyamine, polystyrene, and aliphatic.

[0177] The dispersant preferably includes one or more types of functional groups selected from amine containing groups, hydroxyl groups, carboxyl groups, carboxyl group containing groups, sulfo groups, phosphate groups, or epoxy groups. In particular, a polyacrylic dispersant having amine containing groups as the functional groups is preferable. The dispersant including any of the above functional groups can adsorb on the surface of the organic-inorganic hybrid infrared absorbing particles and more reliably prevent the agglomeration of the organic-inorganic hybrid infrared absorbing particles. Therefore, the organic-inorganic hybrid infrared absorbing particles can be dispersed more uniformly, and the dispersant including any of the above functional groups can be suitably used.

[0178] Examples of the dispersant include Solsperse (registered trademark) (hereinafter the same) 9000, 12000, 17000, 20000, 21000, 24000, 26000, 27000, 28000, 32000, 35100, 54000, Solthix 250, manufactured by Lubrizol Japan Ltd.; EFKA (registered trademark) (hereinafter the same) 4008, EFKA 4009, EFKA 4010, EFKA 4015, EFKA 4046, EFKA 4047, EFKA 4060, EFKA 4080, EFKA 7462, EFKA 4020, EFKA 4050, EFKA 4055, EFKA 4585, EFKA 4400, EFKA 4401, EFKA 4402, EFKA 4403, EFKA 4300, EFKA 4320, EFKA 4330, EFKA 4340, EFKA 6220, EFKA 6225, EFKA 6700, EFKA 6780, EFKA 6782, EFKA 8503, manufactured by EFKA additives B.V.; AJISPER (registered trademark) (hereinafter the same) PB821, AJISPER PB822, AJISPER PB824, AJISPER PB881, FAMEX L-12, manufactured by Ajinomoto Fine-Techno Co., Inc.; DisperBYK (registered trademark) (hereinafter the same) 101, DisperBYK 106, DisperBYK 108, DisperBYK 116, DisperBYK 130, DisperBYK 140, DisperBYK 142, DisperBYK 145, DisperBYK 161, DisperBYK 162, DisperBYK 163, DisperBYK 164, DisperBYK 166, DisperBYK 167, DisperBYK 168, DisperBYK 171, DisperBYK 180, DisperBYK 182, DisperBYK 2000, DisperBYK 2001, DisperBYK 2009, DisperBYK 2013, DisperBYK 2022, DisperBYK 2025, DisperBYK 2050, DisperBYK 2155, DisperBYK 2164, BYK 350, BYK 354, BYK 355, BYK 356, BYK 358, BYK 361, BYK 381, BYK 392, BYK 394, BYK 300, BYK 3441, manufactured by BYK Japan KK; DISPARLON (registered trademark) (hereinafter the same) 1831, DISPARLON 1850, DISPARLON 1860, DISPARLON DA-400N, DISPARLON DA-703-50, DISPARLON DA-725, DISPARLON DA-705, DISPARLON DA-7301, DISPARLON DN-900, DISPARLON NS-5210, DISPARLON NVI-8514L, manufactured by Kusumoto Chemicals, Ltd.; TERPLUS (registered trademark) MD1000, D1180, D1130, manufactured by Otsuka Chemical Co., Ltd.

Method (b):

[0179]

(a) A master batch containing organic-inorganic hybrid infrared absorbing particles is prepared by a method similar to that described above and the like, and the master batch and a master batch made of polyethylene terephthalate without adding the organic-inorganic hybrid infrared absorbing particles are melt-mixed near the melting temperature of the resin to achieve a desired mixing ratio and spun according to a known method.

Method (c):

[0180] For example, a case where urethane fiber is used as the fiber will be described.

[0181] A polymer diol containing organic-inorganic hybrid infrared absorbing particles is reacted with an organic diisocyanate in a twin-screw extruder to synthesize an isocyanate group-terminated prepolymer, and a chain extender is reacted to produce a polyurethane solution (a starting material polymer). The polyurethane solution is spun according to various known methods.

Method (d):

[0182] For example, a case where the organic-inorganic hybrid infrared absorbing particles are attached to the surface of the natural fiber will be described.

[0183] First, a treatment liquid is prepared by mixing the organic-inorganic hybrid infrared absorbing particles, one or more types of binder resins selected from acrylic, epoxy, urethane, and polyester, and a solvent such as water.

[0184] Next, the natural fiber is immersed in the prepared treatment liquid, or the prepared treatment liquid is impregnated into the natural fiber by padding, printing, or spraying, and dried. As a result, the organic-inorganic hybrid infrared absorbing particles can be attached to the natural fiber. The method described in (d) can be applied to any one of: in addition to the natural fiber described above, a semisynthetic fiber, a reclaimed fiber, and an inorganic fiber; a blended yarn, a doubled yarn, and a combined filament yarn of these fibers; and the like.

[0185] When carrying out the methods described in (a) to (d), the dispersion method for dispersing the organic-inorganic hybrid infrared absorbing particles in the solvent (dispersion medium) is not particularly limited, and any method can be used as long as the organic-inorganic hybrid infrared absorbing particles can be uniformly dispersed in a liquid, that is, a solvent. For example, a method such as a medium stirring mill, a ball mill, a sand mill, an ultrasonic dispersion, or the like can be suitably applied.

[0186] The solvent of the organic-inorganic hybrid infrared absorbing particles is not particularly limited but can be selected according to the fiber to be mixed. For example, one or more types selected from common organic solvents such as alcohols, ethers, esters, ketones, aromatic compounds, and the like, and water, can be used.

[0187] Further, when the organic-inorganic hybrid infrared absorbing particles are attached to or mixed with the fiber or the polymer used as the raw material thereof, the dispersion liquid of the organic-inorganic hybrid infrared absorbing particles may be directly mixed with the fiber or the polymer used as the raw material thereof. As necessary, acid or alkali may be added to the dispersion liquid of the organic-inorganic hybrid infrared absorbing particles to adjust the pH, or various surfactants, coupling agents, and the like may be added to further improve the dispersion stability of the organic-inorganic hybrid infrared absorbing particles.

[0188] The content of the organic-inorganic hybrid infrared absorbing particles contained in the infrared absorbing fiber according to the present embodiment is not particularly limited. For example, the percentage of the organic-inorganic hybrid infrared absorbing particles in the infrared absorbing fiber according to the present embodiment is preferably 0.001 mass% or more and 80 mass% or less. Further, when considering the weight of the infrared absorbing fiber after the addition of the organic-inorganic hybrid infrared absorbing particles and the raw material cost, the percentage of the organic-inorganic hybrid infrared absorbing particles in the infrared absorbing fiber is more preferably 0.005 mass% or more and 50 mass% or less.

[0189] When the percentage of the organic-inorganic hybrid infrared absorbing particles in the infrared absorbing fiber is 0.001 mass% or more, a sufficient infrared absorption effect can be obtained even when the fabric using the infrared absorbing fiber is thin, for example.

[0190] Further, it is preferable that the percentage of the organic-inorganic hybrid infrared absorbing particles of the infrared absorbing fiber is 80 mass% or less, because it is possible to prevent a reduction of spinning ability due to filter clogging, thread breakage, and other problems in the spinning process. Particularly, it is even more preferable that the percentage is 50 mass% or less. It is preferable because the additive amount of the organic-inorganic hybrid infrared absorbing particles is reduced, and the physical properties of the fiber are hardly compromised.

[0191] As described above, according to the infrared absorbing fiber according to the present embodiment, by placing the infrared absorbing particles on the interior or the surface of the fiber, it is possible to provide a fiber which efficiently absorbs infrared rays from sunlight and the like and has excellent heat retention. In addition, because the infrared absorbing fiber according to the present embodiment has high chemical resistance properties, the infrared absorption properties do not deteriorate even when exposed to an environment of chemicals such as acids or alkalis at high temperatures. As a result, the infrared absorbing fiber according to the present embodiment can be used for various applications such as fiber products such as cold weather clothing, sports clothing, stockings, curtains, and the like, and other industrial fiber products, and the like, that require heat retention.

[Fiber Product]

[0192] The fiber product according to the present embodiment may be made by processing the infrared absorbing fiber described above, and may include the infrared absorbing fiber described above. The fiber product according to the present embodiment may also be made of the infrared absorbing fiber described above.

[0193] The fiber product according to the present embodiment including the infrared absorbing fiber has excellent characteristics having a visible light absorption of 20% or less and a solar radiation absorption of 47% or more. When the visible light absorption is 20% or less and the solar radiation absorption is 47% or more, it indicates that the fiber product is light-colored and has an excellent infrared absorption effect.

[0194] The fiber product according to the present embodiment including the infrared absorbing fiber according to the present embodiment has excellent chemical resistance properties. For example, even when the fiber product is immersed in a 0.01 mol/l sodium hydroxide aqueous solution held at 80°C for 30 minutes, the solar radiation absorption described above is maintained at 47% or more. That is, the fiber product according to the present embodiment can have chemical resistance properties.

Example

[0195] Hereinafter, the present invention will be specifically described with reference to examples. However, the present invention is not limited to the following examples.

[0196] The optical properties of the fiber products obtained in the Examples and Comparative Examples were measured using a spectrophotometer U-4100 (manufactured by Hitachi, Ltd.). The visible light transmittance, visible light reflectance, solar radiation transmittance, and solar radiation reflectance were measured according to JIS R 3106.

[0197] To measure the crystallite size of infrared absorbing particles, dry powder of infrared absorbing particles obtained by removing the solvent from the dispersion liquid of infrared absorbing particles was used. The X-ray diffraction pattern of the infrared absorbing particles was measured by powder X-ray diffraction method (Θ-2Θ method) using a powder X-ray diffractometer (X'Pert-PRO/MPD manufactured by PANalytical, Spectris Co., Ltd.). The crystal structure included in the infrared absorbing particles was identified from the obtained X-ray diffraction pattern, and the crystallite size was calculated using Rietveld method.

[Example 1]

[0198] Infrared absorbing fibers and fiber products were prepared and evaluated by the following procedure.

1. Production of Organic-Inorganic Hybrid Infrared Absorbing Particles

[0199] Organic-inorganic hybrid infrared absorbing particles for use in an infrared absorbing fiber were produced according to the following step.

(Dispersion Liquid Preparation Step)

[0200] In the dispersion liquid preparation step, a dispersion liquid containing infrared absorbing particles, a dispersant, and a dispersion medium was prepared.

[0201] As the infrared absorbing particles, a composite tungsten oxide powder (YM-01, manufactured by Sumitomo Metal Mining Co., Ltd.) containing hexagonal cesium tungsten bronze ($Cs_{0.33}WO_z$, $2.0 \leq z \leq 3.0$), whose ratio of cesium (Cs) to tungsten (W) in amount of substance is Cs/W=0.33, was prepared.

[0202] As the dispersant, a polymer dispersant, which is a copolymer of styrene and 2-(dimethylamino) ethyl methacrylate, was prepared.

[0203] As the dispersion medium, toluene was prepared.

[0204] A liquid mixture obtained by mixing 10 mass% of the infrared absorbing particles, 3 mass% of the dispersant, and 87 mass% of the dispersion medium was loaded into a paint shaker containing 0.3 mmφ ZrO_2 beads and subjected to pulverizing and dispersing treatment for 10 hours, and a dispersion liquid of $Cs_{0.33}WO_z$ particles according to Example 1 was obtained.

(Dispersion Medium Reduction Step)

[0205] Toluene of the dispersion medium was removed from the dispersion liquid of $Cs_{0.33}WO_z$ particles obtained in the dispersion liquid preparation step using an evaporator, and the infrared absorbing particles were collected. The collected infrared absorbing particles were to be a dry powder of $Cs_{0.33}WO_z$ particles including a polymer dispersant.

[0206] The crystallite size of the collected infrared absorbing particles, that is, $Cs_{0.33}WO_z$ particles, was measured to be 16 nm.

[0207] The crystallite size was measured and calculated by the method described above.

(Raw Material Liquid Mixture Preparation Step)

[0208] 0.05 g of the infrared absorbing particles obtained in the dispersion medium reduction step, 1.0 g of styrene as a raw material for a coating resin, and 0.065 g of hexadecane as an organic solvent were mixed to form an organic phase.

[0209] Separately from the organic phase, dodecyltrimethylammonium chloride as an emulsifier, 0.013 g of 2,2'-azobis(2-methylpropionamidine) dihydrochloride (V-50) as a polymerization initiator, and water were mixed to form 10 g of an aqueous phase. When the aqueous phase was formed, dodecyltrimethylammonium chloride as the emulsifier was added to the water so that the concentration was 1.5 times the critical micelle concentration. The polymerization initiator was added at 0.5 mol% of styrene added to the organic phase.

[0210] Then, a raw material liquid mixture was prepared by adding the organic phase to the aqueous phase.

(Stirring Step)

[0211] The raw material liquid mixture prepared in the raw material liquid mixture preparation step was irradiated with high-power ultrasonic waves for 15 minutes while cooling under an ice bath, and a mini-emulsion was obtained.

(Polymerization Step)

[0212] After the stirring step, the raw material liquid mixture was subjected to nitrogen bubbling under an ice bath for 15 minutes and deoxygenated.

[0213] Thereafter, the polymerization reaction of styrene was carried out by heating at 70°C for 6 hours under a nitrogen atmosphere, and a dispersion liquid of organic-inorganic hybrid infrared absorbing particles was obtained.

[0214] The obtained dispersion liquid containing the organic-inorganic hybrid infrared absorbing particles was diluted and transferred to a microgrid for TEM observation, and TEM observation of the transferred material was carried out. The TEM image is presented in FIG. 2. From the TEM image, it was confirmed that particles 21 including the composite tungsten oxide, which are infrared absorbing particles and are presented in black, are encapsulated in a coating film 22 of polystyrene, which is a coating resin and is presented in gray, to form organic-inorganic hybrid infrared absorbing particles 23. When the organic-inorganic hybrid infrared absorbing particles were visually checked, it was observed that they were light-colored. A microgrid 24 is also presented in FIG. 2, but it is not included in the organic-inorganic hybrid infrared absorbing particles.

2. Production of Infrared Absorbing Fiber

[0215] The obtained dispersion liquid of the organic-inorganic hybrid infrared absorbing particles was mixed with a water-soluble acrylic binder resin, and a treatment liquid was prepared. The prepared treatment liquid was then impregnated with polyester-based fibers and dried, and an infrared absorbing fiber according to Example 1 to which the organic-inorganic hybrid infrared absorbing particles were attached, was prepared.

3. Production of Fiber Product

[0216] The obtained infrared absorbing fiber was cut to produce polyester staples, which were used to produce a spun yarn. A knit product according to Example 1 was obtained using the spun yarn. The solar radiation absorption of the knit product samples was adjusted to be around 50%. It was also adjusted in the following Comparative Example.

4. Evaluation of Fiber Product

[0217] The optical properties of the fiber product according to Example 1 were measured by the method described above. The visible light absorption and the solar radiation absorption were calculated by "visible light absorption (%) = 100% - visible light transmittance (%) - visible light reflectance (%)" and "solar radiation absorption (%) = 100% - solar radiation transmittance (%) - solar radiation reflectance (%)". The calculated visible light absorption and solar radiation absorption were 18% and 51%, respectively. When the color tone of the knit product was visually checked, it was light-colored.

5. Evaluation of Alkali Resistance

[0218] The fiber product according to Example 1 was immersed in 0.01 mol/l sodium hydroxide aqueous solution held at 80°C for 30 minutes, and the alkali resistance test was performed. After that, the optical properties were measured again.

[0219] The visible light absorption and solar radiation absorption after the alkali resistance test were 17% and 49%, respectively. The difference in the visible light absorption and the difference in the solar radiation absorption were 1% and 2%, respectively, when compared before and after the alkali resistance test. The evaluation results are presented in Table 1.

[0220] In other words, it was confirmed that there was no significant change in the light absorption of the infrared absorbing fiber before and after the alkaline resistance test. Therefore, it was confirmed that the infrared absorbing fiber and the fiber product obtained in the present Example have chemical resistance properties, especially alkaline resistance properties.

[Comparative Example 1]

[0221] In the dispersion liquid preparation step, a dispersion liquid containing infrared absorbing particles and a dispersion medium was prepared.

[0222] As the infrared absorbing particles, a composite tungsten oxide powder (YM-01, manufactured by Sumitomo Metal Mining Co., Ltd.) containing hexagonal cesium tungsten bronze ($Cs_{0.33}WO_z$, $2.0 \leq z \leq 3.0$), whose ratio of cesium (Cs) to tungsten (W) in amount of substance is Cs/W=0.33, was prepared.

[0223] As the dispersion medium, pure water was prepared.

[0224] A liquid mixture obtained by mixing 10 mass% of the infrared absorbing particles and 90 mass% of the dispersion medium was loaded into a paint shaker containing 0.3 mmφ ZrO_2 beads and subjected to pulverizing and dispersing treatment for 10 hours, and a dispersion liquid of $Cs_{0.33}WO_z$ particles according to Comparative Example 1 was obtained.

[0225] Pure water of the dispersion medium was removed from the dispersion liquid of $Cs_{0.33}WO_z$ particles obtained in the dispersion liquid preparation step using an evaporator, and the infrared absorbing particles were collected. The collected infrared absorbing particles were to be a dry powder of $Cs_{0.33}WO_z$ particles.

[0226] The crystallite size of the collected infrared absorbing particles, that is, $Cs_{0.33}WO_z$ particles, was measured to be 16 nm.

[0227] The crystallite size was measured and calculated by the method described above.

[0228] The infrared absorbing fiber and the fiber product according to Comparative Example 1 were obtained by the same operation as in Example 1 except that the dispersion liquid of $Cs_{0.33}WO_z$ particles according to Comparative Example 1 that was obtained in the dispersion liquid preparation step was used instead of the dispersion liquid of the organic-inorganic hybrid infrared absorbing particles according to Example 1. The obtained fiber product was evaluated in the same manner as in Example 1. The evaluation results are presented in Table 1.

[Table 1]

	BEFORE ALKALI RESISTANCE TEST		AFTER ALKALI RESISTANCE TEST	
	VISIBLE LIGHT ABSORPTION	SOLAR RADIATION ABSORPTION	VISIBLE LIGHT ABSORPTION	SOLAR RADIATION ABSORPTION
	[%]	[%]	[%]	[%]
EXAMPLE 1	18	51	17	49
COMPARATIVE EXAMPLE 1	19	51	1	4

From the results of the evaluation of the optical properties of the fiber product before and after the alkali resistance test presented in Table 1 above, it was confirmed that there was no significant change in the light absorption properties of the fiber product using the organic-inorganic hybrid infrared absorbing particles of Example 1, in which the coating resin was located on at least a part of the surface of the infrared absorbing particles.

[0229] Therefore, it was confirmed that the infrared absorbing fiber using the organic-inorganic hybrid infrared absorbing particles of Example 1 and the fiber product containing the infrared absorbing fiber had excellent alkaline resistance properties, that is, excellent chemical resistance properties, and excellent infrared absorption properties. Although only an alkali resistance test was performed here, these organic-inorganic hybrid infrared absorbing particles also have acid resistance properties because the coating resin is located on at least a part of the surface of the infrared absorbing particles.

[0230] In contrast, in the fiber product using the infrared absorbing particles of Comparative Example 1, the infrared absorption properties disappeared after the alkali resistance test, and it was confirmed that the fiber product does not have alkali resistance properties.

[0231] Although the infrared absorbing fiber and the fiber product have been described in the above embodiments and examples, the present invention is not limited to the above embodiments and examples. Various modifications and changes can be made within the scope of the present invention described in the claims.

Claims

1. An infrared absorbing fiber comprising:

a fiber; and
organic-inorganic hybrid infrared absorbing particles,
wherein the organic-inorganic hybrid infrared absorbing particles include infrared absorbing particles and a coating resin that covers at least a part of a surface of the infrared absorbing particles, and
wherein the organic-inorganic hybrid infrared absorbing particles are located in one or more parts selected from an interior of the fiber and a surface of the fiber.

2. The infrared absorbing fiber according to claim 1, wherein the coating resin includes one or more resins selected from polyester resin, polycarbonate resin, acrylic resin, polystyrene resin, polyamide resin, vinyl chloride resin, olefin resin, fluorine resin, polyvinyl acetate resin, polyurethane resin, acrylonitrile butadiene styrene resin, polyvinyl acetal resin, acrylonitrile-styrene copolymer resin, ethylene-vinyl acetate copolymer resin, phenol resin, epoxy resin, melamine resin, urea resin, unsaturated polyester resin, alkyd resin, polyimide resin, and silicone resin.

3. The infrared absorbing fiber according to claim 2,

wherein the coating resin is a photocurable resin, and
wherein the photocurable resin includes a resin to be cured by irradiation of any one of ultraviolet light, visible light, or infrared light.

4. The infrared absorbing fiber according to any one of claims 1 to 3,
wherein the infrared absorbing particles include one or more oxides selected from a tungsten oxide represented by a general formula W_yO_z where W is tungsten and O is oxygen and z/y is 2.2 or more and 2.999 or less and a composite tungsten oxide represented by a general formula $M_xW_yO_z$ where an element M is one or more elements selected from H, He, an alkali metal, an alkaline earth metal, a rare earth element, Mg, Zr, Cr, Mn, Fe, Ru, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Al, Ga, In, Tl, Si, Ge, Sn, Pb, Sb, B, F, P, S, Se, Br, Te, Ti, Nb, V, Mo, Ta, Re, Be, Hf, Os, Bi, and I, x/y is 0.001 or more and 1 or less, and z/y is 2.0 or more and 3.0 or less.

5. The infrared absorbing fiber according to any one of claims 1 to 4, wherein the fiber includes one or more fibers selected from a synthetic fiber, a semisynthetic fiber, a natural fiber, a reclaimed fiber, and an inorganic fiber.

6. The infrared absorbing fiber according to claim 5, wherein the synthetic fiber includes one or more fibers selected from a polyurethane fiber, a polyamide fiber, an acrylic fiber, a polyester fiber, a polyolefin fiber, a polyvinyl alcohol fiber, a polyvinylidene chloride fiber, a polyvinyl chloride fiber, and a polyether ester fiber.

7. The infrared absorbing fiber according to claim 5 or 6, wherein the semisynthetic fiber includes one or more types selected from a cellulose fiber, a protein fiber, chlorinated rubber, and hydrochlorinated rubber.

8. The infrared absorbing fiber according to any one of claims 5 to 7, wherein the natural fiber includes one or more fibers selected from a vegetable fiber, an animal fiber, and a mineral fiber.

9. The infrared absorbing fiber according to any one of claims 5 to 8, wherein the reclaimed fiber includes one or more fibers selected from a cellulose fiber, a protein fiber, an algin fiber, a rubber fiber, a chitin fiber, and a mannan fiber.

10. The infrared absorbing fiber according to any one of claims 5 to 9, wherein the inorganic fiber includes one or more fibers selected from a metal fiber, a carbon fiber, and a silicate fiber.

11. A fiber product comprising the infrared absorbing fiber of any one of claims 1 to 10.

FIG.1

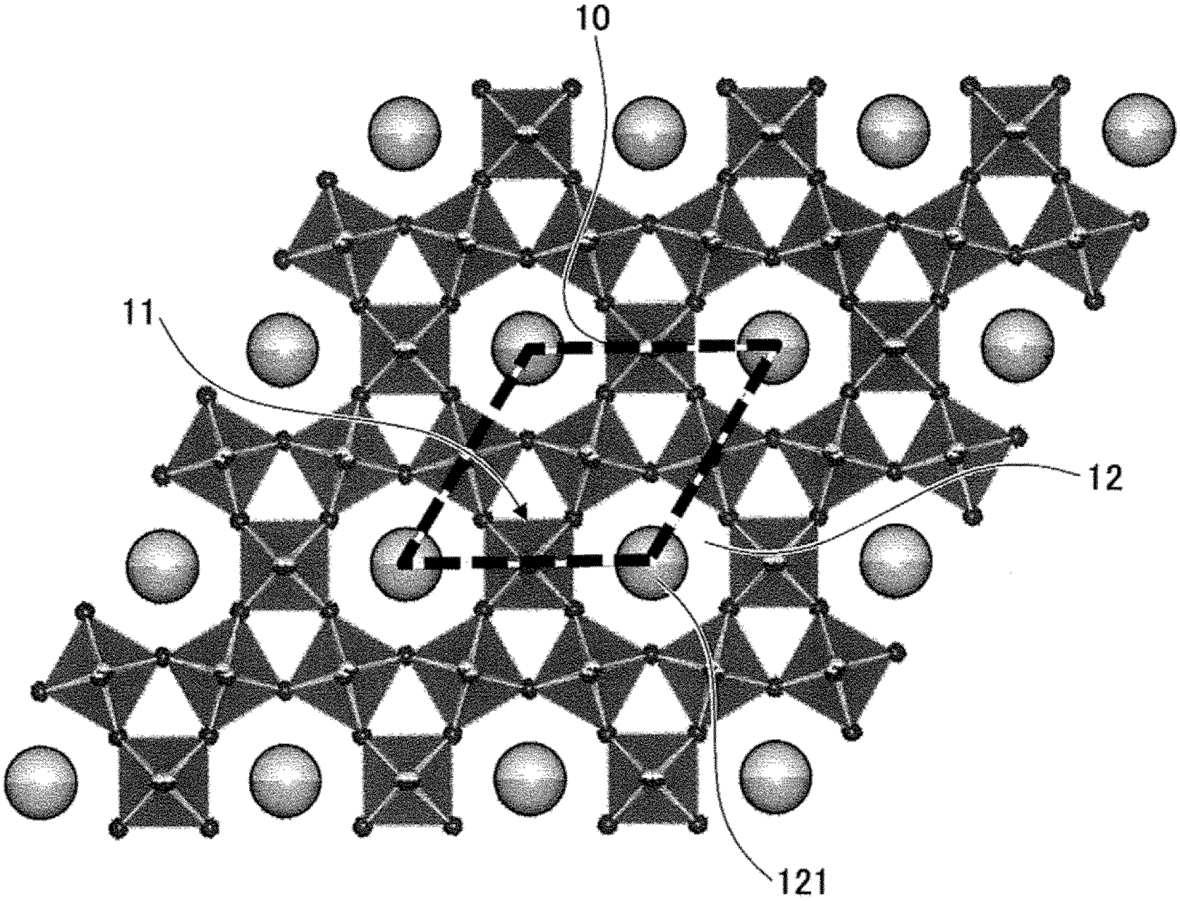
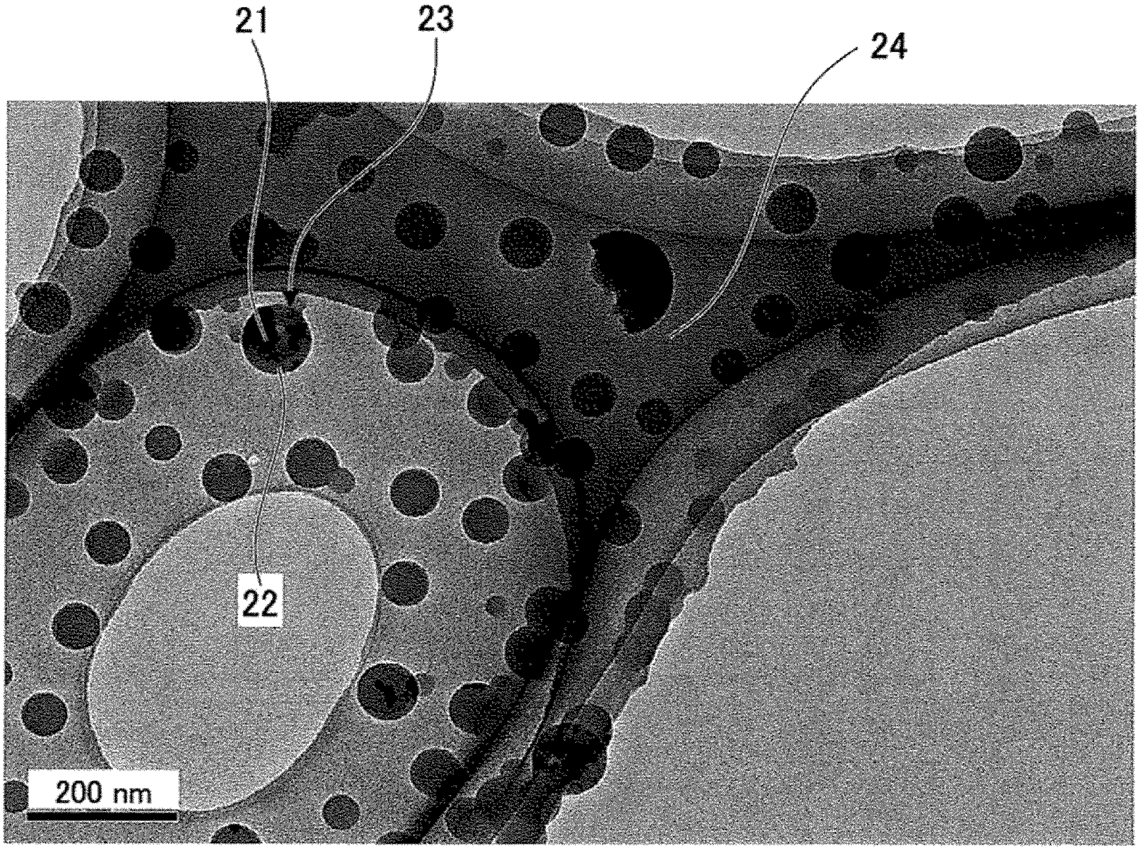


FIG.2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/015721

A. CLASSIFICATION OF SUBJECT MATTER
D01F 1/10(2006.01)i; C01G 41/00(2006.01)i; D06M 11/32(2006.01)i; D06M 11/48(2006.01)i; D06M 23/08(2006.01)i
FI: D01F1/10; D06M11/32; D06M11/48; D06M23/08; C01G41/00 A
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D01F1/00-6/96,9/00-9/04; C01G41/00-41/04; D06M11/00-11/84; D06M23/00-23/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2020/129919 A1 (SUMITOMO METAL MINING CO) 25 June 2020 (2020-06-25) claims 14-17, paragraph [0105]	1-4, 11 1-11
Y	JP 2006-132042 A (SUMITOMO METAL MINING CO LTD) 25 May 2006 (2006-05-25) claims 1, 3-4, 7-1215, paragraphs [0001], [0060]	1-11
E, X	JP 2021-75825 A (SUMITOMO METAL MINING CO) 20 May 2021 (2021-05 20) claims 1-11	1-11
A	JP 2020-75989 A (KYODO PRINTING CO LTD) 21 May 2020 (2020-05-21) entire text	1-11

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 24 June 2021 (24.06.2021)	Date of mailing of the international search report 13 July 2021 (13.07.2021)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/015721

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 2019/021992 A1 (SUMITOMO METAL MINING CO) 31 January 2019 (2019-01 31) entire text	1-11
A	CN 102337603 A (INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE) 01 February 2012 (2012-02-01) whole document	1-11

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/JP2021/015721

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JP 2006-132042 A	25 May 2006	US 2008/0308775 A1 claims 1, 3-4, 7-12, 15, paragraphs [0001], [0088] WO 2006/049025 A1 EP 1847635 A1 KR 10-2007-0085850 A CN 101052755 A	
JP 2021-75825 A	20 May 2021	(Family: none)	
JP 2020-75989 A	21 May 2020	(Family: none)	
JP 2020-26595 A	20 Feb. 2020	(Family: none)	
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