

(19)



(11)

EP 4 585 728 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.07.2025 Bulletin 2025/29

(51) International Patent Classification (IPC):
D01F 1/10 (2006.01)

(21) Application number: **24194856.1**

(52) Cooperative Patent Classification (CPC):
D01F 1/10

(22) Date of filing: **16.08.2024**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

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(54) **FUNCTIONAL FILAMENT, ULTRAFINE FUNCTIONAL FIBER AND USES OF THE SAME**

(57) A functional filament is provided. The functional filament comprises a polymer matrix and functional nanoparticles dispersed within the polymer matrix. The functional filament has a cross-sectional diameter ranging

from 1 μm to 30 μm , and the functional nanoparticles comprise element(s) selected from the group consisting of Au, Ag, Ti, Ge, Zn, Al, Mg, Si, Cu, Ca, Fe, Ba, K, Na, Mn, Ni, Ga, Pt, and combinations thereof.

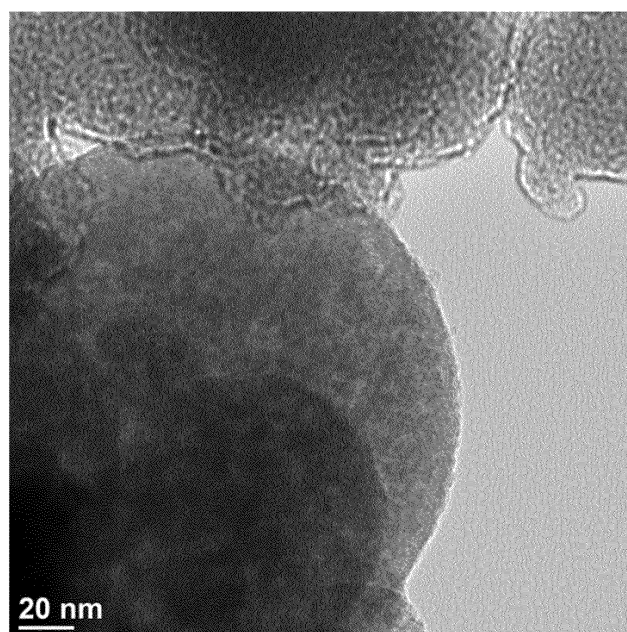


Fig. 1

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention provides a functional filament, especially a containing functional filament having a cross-sectional diameter of only 1 μm to 30 μm and containing functional nanoparticles. The present invention also provides an ultrafine functional fiber comprising the functional filament and a functional fabric comprising the functional filament.

Descriptions of the Related Art

[0002] In the textile industry, a fiber refers to a yarn formed by twisting multiple filaments. With the development of textile technology, the diameter of filaments constituting fibers has been reduced to a few micrometers, enabling the production of fabrics made from ultrafine filaments with a soft texture and fine feel, particularly suitable for manufacturing underwear.

[0003] Due to the awareness of health preservation, functional fibers containing functional nanoparticles with special functions have emerged. Among these, far-infrared fibers containing far-infrared radiation particles have experienced significant growth. Far-infrared fibers can facilitate blood circulation and metabolism.

[0004] Generally, functional fibers are prepared by adding functional particles (e.g., metal particles that can emit far-infrared radiation) into a masterbatch for manufacturing filaments, and then twisting the filaments containing functional particles into functional fibers. However, due to the size limitation of functional particles, the diameter of filaments containing functional particles cannot currently reach the micrometer scale. Consequently, fabrics manufactured from fibers twisted from such filaments cannot achieve a satisfactory level of softness and texture.

SUMMARY OF THE INVENTION

[0005] The present invention provides a new functional filament. The technical problems to be resolved by the present invention is that in the prior art, functional particles are generally ground to reduce the size of functional materials. However, this approach has a technical bottleneck, making it impossible produce functional filaments with micrometer dimensions. After continuous research, the inventor has successfully overcome the technical bottleneck of the prior art and successfully produced functional filaments with micrometer dimensions. These functional filaments can be twisted to form ultrafine functional fibers, and fabrics made from these fibers can achieve a satisfactory level of softness and texture, making them particularly suitable for use in infant garments or underwear.

[0006] Therefore, an objective of the present invention is to provide a functional filament, comprising a polymer matrix and functional nanoparticles dispersed within the polymer matrix, wherein the functional filament has a cross-sectional diameter ranging from 1 μm to 30 μm , and the functional nanoparticles comprise element(s) selected from the group consisting of Au, Ag, Ti, Ge, Zn, Al, Mg, Si, Cu, Ca, Fe, Ba, K, Na, Mn, Ni, Ga, Pt, and combinations thereof.

[0007] In some embodiments of the present invention, the cross-sectional diameter of the functional filament ranges from 5 μm to 20 μm .

[0008] In some embodiments of the present invention, an average particle size of the functional nanoparticles ranges from 1 nm to 300 nm.

[0009] In some embodiments of the present invention, the functional nanoparticles comprise Fe, Ti and Ca.

[0010] In some embodiments of the present invention, the functional nanoparticles further comprise element(s) selected from the group consisting of Al, Ba, Cu, Fe, Mg, Ni, Zn, Mn, and combinations thereof.

[0011] In some embodiments of the present invention, the polymer matrix is selected from the group consisting of polyester, polyurethane (PU), poly(vinyl chloride) (PVC), polypropylene (PP), polyamide (PA), an amino-comprising polymer, silicone, and mixtures thereof.

[0012] In some embodiments of the present invention, the polymer matrix comprises polyester.

[0013] Another objective of the present invention is to provide an ultrafine functional fiber, which comprises the aforementioned functional filament.

[0014] In some embodiments of the present invention, a fiber fineness of the ultrafine functional fiber is less than 0.7 denier.

[0015] Yet another objective of the present invention is to provide a functional fabric, which is manufactured from a fiber material, wherein the fiber material comprises the aforementioned ultrafine functional fiber.

[0016] To render the above objectives, technical features and advantages of the present invention more apparent, the present invention will be described in detail with reference to some embodiments hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a scanning electron microscopy image of functional nanoparticles used in the production of the functional filaments of the present invention.

Fig. 2 is a scanning electron microscopy image of the functional filaments of the present invention.

Fig. 3 is a filter pressure rising curve of the functional masterbatch.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] Hereinafter, some embodiments of the present invention will be described in detail. However, the present invention may be embodied in various embodiments and should not be limited to the embodiments described in the specification.

[0019] Unless otherwise specified, the expressions "a," "the," or the like recited in the specification and in the claims should include both the singular and the plural forms.

[0020] Unless otherwise specified, the expressions "first", "second" or the like recited in this specification and claims are solely for distinguishing the described elements or constituents and do not imply any special meanings or any particular order.

[0021] As used herein, an "ultrafine functional fiber" refers to a fiber with a fiber fineness less than 0.7 denier.

[0022] The present invention provides a functional filament with a cross-sectional diameter of 30 μm or less. The functional filament can be used to prepare soft and fine-textured ultrafine functional fibers, and the functional nanoparticles contained therein can provide the desired specific functions (e.g., far-infrared radiation emission). The following provides a detailed description of the functional filament of the present invention and applications thereof.

1. Functional filament

[0023] The functional filament of the present invention comprises a polymer matrix and functional nanoparticles dispersed within the polymer matrix. The cross-sectional diameter of the functional filament of the present invention can be as low as 30 μm or less. Specifically, the cross-sectional diameter of the functional filament can range from 1 μm to 30 μm . For example, the cross-sectional diameter of the functional filament can be 1 μm , 1.5 μm , 2 μm , 2.5 μm , 3 μm , 3.5 μm , 4 μm , 4.5 μm , 5 μm , 5.5 μm , 6 μm , 6.5 μm , 7 μm , 7.5 μm , 8 μm , 8.5 μm , 9 μm , 9.5 μm , 10 μm , 10.5 μm , 11 μm , 11.5 μm , 12 μm , 12.5 μm , 13 μm , 13.5 μm , 14 μm , 14.5 μm , 15 μm , 15.5 μm , 16 μm , 16.5 μm , 17 μm , 17.5 μm , 18 μm , 18.5 μm , 19 μm , 19.5 μm , 20 μm , 20.5 μm , 21 μm , 21.5 μm , 22 μm , 22.5 μm , 23 μm , 23.5 μm , 24 μm , 24.5 μm , 25 μm , 25.5 μm , 26 μm , 26.5 μm , 27 μm , 27.5 μm , 28 μm , 28.5 μm , 29 μm , 29.5 μm , or 30 μm , or within a range between any two of the values described herein. In a preferred embodiment of the present invention, the cross-sectional diameter of the functional filament ranges from 1 μm to 20 μm , more specifically, from 5 μm to 20 μm .

1.1. Functional nanoparticle

[0024] The functional filament of the present invention contains functional nanoparticles to provide the desired specific functions. Specifically, the functional nanoparti-

cles comprise the element(s) selected from the following group to provide a far-infrared emitting function: Au, Ag, Ti, Ge, Zn, Al, Mg, Si, Cu, Ca, Fe, Ba, K, Na, Mn, Ni, Pt, and Ga. The aforementioned elements can be used alone or in a mixture of two or more. For example, the functional nanoparticles may comprise the following element(s): Ti; Ti and Au; Au and Pt; Au, Pt and Na; Ti, Au, Pt and Na; Ti, Au, Ge and Zn; or Au, Ti, Ge, Zn, Al, Mg and Na. In some embodiments of the present invention, the functional nanoparticles comprise Ti, Fe and Ca. In some embodiments of the present invention, the functional nanoparticles comprise Ti, Fe, Ca, and one or more selected from Al, Ba, Cu, Fe, Mg, Ni, Zn, and Mn. In the appended examples, the functional nanoparticles comprise Ti, Fe, Ca, Al, Zn, Ba, Cu, Mg and Ni. The functional filament of the present invention can emit far-infrared radiation with a wavelength range particularly good for the human body, specifically, far-infrared radiation with a wavelength ranging from 2 μm to 22 μm , particularly with a wavelength ranging from 4 μm to 14 μm , especially including far-infrared radiation with a wavelength ranging from 6 μm to 6.5 μm . Consequently, fabrics made from the functional filament of the present invention can increase the user's blood flow and circulation rate while maintaining normal body surface temperature, blood pressure, and pulse rate in a safe manner.

[0025] To ensure that the functional filament of the present invention has a cross-sectional diameter of 30 μm or less while providing desired functions, the average particle size of the functional nanoparticles is controlled within a specific range. In some embodiments of the present invention, the average particle size of the functional nanoparticles ranges from 1 nm to 300 nm. For example, the average particle size of the functional nanoparticles can be 1 nm, 5 nm, 10 nm, 15 nm, 20 nm, 25 nm, 30 nm, 35 nm, 40 nm, 45 nm, 50 nm, 55 nm, 60 nm, 65 nm, 70 nm, 75 nm, 80 nm, 85 nm, 90 nm, 95 nm, 100 nm, 105 nm, 110 nm, 115 nm, 120 nm, 125 nm, 130 nm, 135 nm, 140 nm, 145 nm, 150 nm, 155 nm, 160 nm, 165 nm, 170 nm, 175 nm, 180 nm, 185 nm, 190 nm, 195 nm, 200 nm, 205 nm, 210 nm, 215 nm, 220 nm, 225 nm, 230 nm, 235 nm, 240 nm, 245 nm, 250 nm, 255 nm, 260 nm, 265 nm, 270 nm, 275 nm, 280 nm, 285 nm, 290 nm, 295 nm, or 300 nm, or within a range between any two of the values described herein.

[0026] In addition, the far-infrared radiation rate of the functional nanoparticles is at least 90%. For example, the far-infrared radiation rate of the functional nanoparticles can be 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%, or within a range between any two of the values described herein.

[0027] Generally, the methods of preparing nanoparticles can be broadly classified into the gas condensation method, the liquid phase reduction method, and the mechanical alloying method. Examples of the liquid phase reduction method include, but are not limited to, coprecipitation, sol-gel method, micro-emulsion method, hydrothermal/solvothermal synthesis, template method,

and biomimetic synthesis. To facilitate the formation of formulations and masterbatches for preparing the functional filament and the dispersion of the functional nanoparticles in the functional filament, the source of the functional nanoparticles of the functional filament can be functional nanoparticles with a core-shell structure. In some embodiments of the present invention, the source of the functional nanoparticles can be functional nanoparticles with a core-shell structure in which the shell material contains silicon, thereby increasing the compatibility with the polymer matrix and improving the stability of the functional nanoparticles during the preparation of functional filament.

[0028] The aforementioned functional nanoparticles with a core-shell structure can be prepared by the sol-gel method. First, metal precursors containing the aforementioned elements and deionized water are placed in a conical flask, under continuous stirring, the mixture is heated to boiling, and an aqueous solution of sodium citrate is added dropwise to the conical flask during boiling. Then, after continuing to boil for 15 minutes to 25 minutes, the mixture solution in the conical flask is allowed to cool naturally to room temperature. Subsequently, a solution of polyvinylpyrrolidone (PVP) is added to the conical flask, and under continuous stirring, the mixture solution is heated again to 60°C to 80°C and maintained for 20 minutes to 40 minutes to obtain a solution containing metal nanoparticle cores coated with PVP. Then, sodium citrate and a silicon-containing material are added to the solution containing the PVP-coated metal nanoparticle cores, and the pH of the solution is adjusted to 5 to 7 using sodium bicarbonate to react and obtain functional nanoparticles with a core-shell structure.

[0029] Examples of the aforementioned metal precursors include, but are not limited to, hydrogen tetrachloroaurate (HAuCl_4), titanium tetrachloride (TiCl_4), titanium tetrapropoxide, titanium n-butoxide, platinum tetrachloride, platinum(II) bis(acetylacetonate), silver nitrate, zinc chloride, zinc nitrate, and the like.

[0030] Examples of the aforementioned silicon-containing material include, but are not limited to, silane, siloxane, silyl ether, silanol, siloxide, silyl chloride, and silazole. Examples of silane include, but are not limited to, methylsilane, methyltrimethoxysilane, methyltriethoxysilane, propyltrimethoxysilane, isobutyltrimethoxysilane, isobutyltriethoxysilane, n-octyltriethoxysilane, vinyltrimethoxysilane, vinyltriethoxysilane, dimethyldimethoxysilane, tetramethoxysilane, tetraethoxysilane (TEOS), ethyltriacetoxysilane, cyclohexylmethyldimethoxysilane, and dicyclopentylmethoxysilane. Examples of siloxane include, but are not limited to, polydimethylsiloxane, polymethylhydrogensiloxane (PMHS), polydiethylsiloxane, polymethyl(3-glycidyloxypropyl) siloxane (PMGS), hexamethyldisiloxane, hexamethylcyclotrisiloxane, octamethyltrisiloxane, octamethylcyclotetrasiloxane, and decamethyltetrasiloxane. Examples of silyl ether include, but are not limited to, trimethylsilyl ether,

triethylsilyl ether, tert-butyldimethylsilyl ether, and triisopropylsilyl ether. Examples of silanol include, but are not limited to, trimethylsilanol, triethylsilanol, and tri-tert-butyilsilanol. In a preferred embodiment of the present invention, the material forming the shell structure of functional nanoparticles comprises silane, siloxane, or the combination thereof. Consequently, preferred examples of the silicon-containing material used for preparing functional nanoparticles include, but are not limited to, methylsilane, methyltrimethoxysilane, methyltriethoxysilane, propyltrimethoxysilane, isobutyltrimethoxysilane, isobutyltriethoxysilane, n-octyltriethoxysilane, vinyltrimethoxysilane, vinyltriethoxysilane, dimethyldimethoxysilane, tetramethoxysilane, tetraethoxysilane, ethyltriacetoxysilane, cyclohexylmethyldimethoxysilane, dicyclopentylmethoxysilane, polydimethylsiloxane, PMHS, polydiethylsiloxane, PMGS, hexamethyldisiloxane, hexamethylcyclotrisiloxane, octamethyltrisiloxane, octamethylcyclotetrasiloxane, and decamethyltetrasiloxane.

1.2. Polymer matrix

[0031] In the functional filament of the present invention, the polymer matrix serves as the main body of the filament, and the functional nanoparticles are dispersed therein. In some embodiments of the present invention, the polymer matrix is selected from the group consisting of polyester, PU, PVC, PP, PA, an amino-comprising polymer, and silicone. The aforementioned polymer matrix can be used alone or in a mixture of two or more. Examples of polyester include, but are not limited to, polyethylene terephthalate (PET), poly(butylene terephthalate) (PBT), and a combination thereof. In the appended examples, the polymer matrix is polyester.

[0032] In addition to the aforementioned functional nanoparticles, the functional filament of the present invention can optionally include other conventional substances to provide additional desired functions. The additional desired functions include, but are not limited to, antibacterial function, anti-static function, ultraviolet radiation protection function, flame retardance function, deodorizing function, and sterilizing function. The selection of relevant conventional substances can be made by those of ordinary skill in the art based on the disclosure of the present specification according to the needs, which will not be further elaborated here.

1.3. Preparation of functional filament

[0033] The functional filament of the present invention can be prepared the full pelletization method, the masterbatch method, or the injection method, and the masterbatch method is preferable. For example, using the masterbatch method, the functional masterbatches and, if necessary a diluting polymer can be mixed in a certain ratio, e.g., the functional masterbatches to the non-functional masterbatches in a weight ratio of 0.5:9.5, 1:9, 1.5:8.5, 2:8, 2.5:7.5, 3:7, 3.5:6.5, 1:3, 2:3, or 1:1, to obtain

a blend. Then, the blend is subjected to a spinning procedure at a high temperature (depending on the type of the polymer) to obtain the functional filament. The functional masterbatches refer to masterbatches containing functional nanoparticles, and the non-functional masterbatches refer to masterbatches not containing functional nanoparticles. The temperature of the spinning procedure must allow the polymer matrix of the masterbatches and the diluting polymer matrix to have fluidity so that the functional nanoparticles can be uniformly distributed in the functional filament. In some embodiments of the present invention, the functional masterbatches and the non-functional masterbatches are mixed in a weight ratio of 3.3:6.7.

[0034] The aforementioned functional masterbatches can be prepared as follows. First, the functional nanoparticles are dispersed in a solvent to form a solution. The solution, a polymer (e.g., PBT) and a dispersant are thoroughly mixed using a high-speed mixer, and then the mixed formulation, polymer and dispersant are melt-extruded at a high temperature using an extruder to obtain the functional masterbatches. Examples of the solvent include, but are not limited to water, isopropanol, or a combination thereof.

[0035] In some embodiments of the present invention, the functional filament is formed as a core-sheath type filament comprising a first polymer core layer and a second polymer sheath layer, wherein the first polymer core layer comprises a first polymer, and the second polymer sheath layer comprises a second polymer. The first polymer and the second polymer together constitute the polymer matrix of the functional filament, and at least one of the first polymer core layer and the second polymer sheath layer contains the functional nanoparticles. The first polymer and the second can be the same or different from each other and can be independently selected from the group consisting of polyester, PU, PVC, PP, PA, silicone, and combinations thereof. Examples of polyester include, but are not limited to, PET, PBT, or a combination thereof.

[0036] The functional filament of the present invention can be manufactured into various cross-sectional shapes, e.g., filaments with circular, oval, triangular, quadrangular or other polygonal, X-shaped, Y-shaped, or cross-shaped cross-sections, but the present invention is not limited thereto. In addition, to achieve lightweight and good elasticity, the functional filament of the present invention can also be manufactured as a hollow filament. Such modifications can be made by those of ordinary skill in the art based on the disclosure of the present specification, which will not be further elaborated here.

2. Ultrafine functional fiber

[0037] The functional filament of the present invention has an extremely low cross-sectional diameter, which can be as low as 30 μm or less. Therefore, the functional

filament of the present invention can be used to form an ultrafine functional fiber with low denier (D) and high filament count (F). Thus, the present invention also provides an ultrafine functional fiber comprising the aforementioned functional filament. The ultrafine functional fiber of the present invention can be formed by bundling the aforementioned functional filaments into a strand. Alternatively, the ultrafine functional fiber of the present invention can be formed by bundling the aforementioned functional filaments and other non-functional filaments to a strand. The non-functional filaments include, but are not limited to, natural filaments and artificial filaments. Examples of natural filaments include, but are not limited to, silk filaments and cotton filaments. Examples of artificial filaments include, but are not limited to, polyester filaments and nylon filaments. The selection of non-functional filaments can be made by those of ordinary skill in the art based on the disclosure of the present specification according to the needs, which will not be further elaborated here. The method of bundling can also be determined by those of ordinary skill in the art based on the disclosure of the present specification according to the needs, which will not be further elaborated here.

[0038] In some embodiments of the present invention, the ultrafine functional fiber comprises polyester as the matrix and has a fiber fineness of less than 0.7 denier. For example, the fiber fineness of the ultrafine functional fiber can be 0.7 denier, 0.65 denier, 0.6 denier, 0.55 denier, 0.5 denier, 0.45 denier, 0.4 denier, 0.35 denier, 0.3 denier, 0.25 denier, 0.2 denier, 0.1 denier, or 0.05 denier. The specifications of the yarn formed from the ultrafine functional fiber of the present invention include, but are not limited to, 20D/36F, 20D/48F, 30D/48F, 30D/72F, 40D/72F, 40D/96F, 50D/96F, 50D/108F, 50D/144F, 75D/108F, 75D/144F, 75D/156F, 80D/144F, 80D/156F, 100D/144F, 100D/156F, 100D/192F, 105D/156F, 105D/192F, 150D/216F, 150D/228F, 150D/288F, 175D/262F, 175D/288F, 200D/288F, 200D/300F, or any D/F value less than 0.7.

[0039] The ultrafine functional fiber of the present invention can have a tensile strength of at least 2.5 g/D (grams/Denier). More specifically, the tensile strength of the ultrafine functional fiber of the present invention can range from 2.5 g/D to 5 g/D. For example, the tensile strength of the ultrafine functional fiber of the present invention can be 2.6 g/D, 2.7 g/D, 2.8 g/D, 2.9 g/D, 3 g/D, 3.1 g/D, 3.2 g/D, 3.3 g/D, 3.4 g/D, 3.5 g/D, 3.6 g/D, 3.7 g/D, 3.8 g/D, 3.9 g/D, 4 g/D, 4.1 g/D, 4.2 g/D, 4.3 g/D, 4.4 g/D, 4.5 g/D, 4.6 g/D, 4.7 g/D, 4.8 g/D, 4.9 g/D, or 5 g/D, or within a range between any two of the values described herein. The aforementioned tensile strength is measured in accordance with ASTM D2256-2002.

3. Functional fabric

[0040] The ultrafine functional fiber of the present invention can be used alone or in combination with other fibers to manufacture various functional fabrics. Thus,

the present invention also provides a functional fabric made from a fiber material comprising the ultrafine functional fiber of the present invention and, if necessary, other fibers. The functional fabrics include, but are not limited to, bedding (such as blankets, mattresses, sheeting, etc.), clothing (such as tops, bottoms, underpants, etc.), chair cushions, eye masks, waist belts, neck protectors, elbow protectors, shawls, and external patches.

[0041] The functional fabric of the present invention has the advantages of soft texture, good skin-friendliness, and good breathability, making it particularly suitable for baby clothing or underwear. Furthermore, the functional nanoparticles contained therein can emit far-infrared rays to facilitate blood circulation and benefiting the metabolism of infants, e.g., helping to reduce neonatal jaundice. Consequently, in a preferred embodiment of the present invention, the functional fabric is a baby swaddle, a baby belly band, a reusable diaper, an intimate wear, underpants, sanitary pants, and the like.

[0042] The softness of the functional fabric of the present invention can be represented by the "stiffness". The stiffness can be evaluated by the cantilever test in accordance with ASTM D1388-14. Generally, when the drape length of a fabric is not greater than 15 mm, the fabric is evaluated as soft. In some embodiments of the present invention, the drape length of the functional fabric is 5.3 mm in the length direction and 6.2 mm in the width direction, indicating excellent softness.

[0043] In addition, the far-infrared emissivity of the functional fabric of the present invention is at least 90%. For example, the far-infrared emissivity of the functional fabric of the present invention can be 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%, or within a range between any two of the values described herein.

4. Example

4.1. Preparation of functional nanoparticles

[Preparation Example 1]

[0044] TiCl_4 and deionized water were placed into a conical flask and heated to boiling under continuous stirring, while an aqueous solution of sodium citrate was added dropwise to the conical flask during boiling to obtain a mixture solution. Then, the mixture solution in the conical flask was boiled for 15 minutes to 25 minutes, followed by naturally cooling to room temperature. Subsequently, a solution of PVP was added to the conical flask, and the mixture solution was heated again to 60°C to 80°C under continuous stirring for 20 minutes to 40 minutes, resulting in a solution containing PVP-coated titanium nanocores. In the second stage, a shell structure formed from tetraethoxysilane (TEOS) was prepared to wrap the PVP-coated titanium nanocores. Initially, sodium citrate and a silicon-containing material were added to the solution comprising PVP-coated titanium nano-

cores, and the pH value of the solution was adjusted to 5 to 7 with sodium bicarbonate to form functional nanoparticles with a core-shell structure, where the shell material is tetraethoxysilane (TEOS) and the core material is titanium nanoparticles. Fig. 1 shows the scanning electron microscopy image of the functional nanoparticles of Preparation Example 1. The average particle size of the functional nanoparticles in Preparation Example 1 is 49.96 nm, and the far-infrared emissivity is 95%.

4.2. Preparation of functional filament and ultrafine functional fibers

[0045] The functional nanoparticles of Preparation Example 1, a dispersant and PBT were thoroughly mixed using a mixer. The mixed functional nanoparticles, dispersant and PBT were extruded using an extruder at a temperature of 230°C to 295°C to obtain functional masterbatches.

[0046] The resultant functional masterbatches were blended with PET excluding functional nanoparticles at a weight ratio of 3.3:6.7 (functional masterbatches:PET excluding functional nanoparticles) to obtain a blend. Then, the blend was extruded using an extruder at 265°C, and then processed through screw spinning, winding, and post-processing steps to obtain functional filaments. The functional filament has a cross-sectional diameter ranging from 5 μm to 20 μm .

[0047] The functional filaments manufactured from Preparation Example 1 was observed using a scanning electron microscope, and the result is shown in Fig. 2. The calculated cross-sectional diameter of the functional filaments was about 13.5 μm . In addition, the functional masterbatches were subjected to a filter pressure rising test in accordance with BS EN 13900-5:2005, and the result is shown in Fig. 3. As can be seen from Fig. 3, under test conditions of 285°C and filter pore size of 20 μm , the pressure before adding functional masterbatches was 35 bar, and the pressure after adding functional masterbatches was 52 bar, stabilizing between 52 bar and 55 bar. These results indicate that the functional masterbatches has good dispersity, does not cause excessive pressure during extrusion leading to shutdown issues, and can extrude stably to avoid filament breakage or filament floating issues, providing the advantage of production stability.

[0048] The functional filaments were then collected to produce ultrafine functional fibers. The resultant ultrafine functional fibers have a denier of 75D/144F. Additionally, the resultant ultrafine functional fiber has a tensile strength ranging from 2.6 g/D to 3.1 g/D measured in accordance with ASTM D2256-2002.

4.3. ICP-OES analysis

[0049] The elements contained within the ultrafine functional fiber were analyzed using an inductively coupled plasma optical emission spectrometer (ICP-OES).

The results of the analysis are as follows: the ultrafine functional fibers contain about 1450 ppm of Ti, about 276 ppm of Fe, about 157 ppm of Ca, about 43 ppm of Al, about 51 ppm of Zn, and less than 30 ppm of Ba, Cu, Mg and Ni. It is confirmed that the ultrafine functional fibers contain more than 1000 ppm of Ti and have far-infrared radiation function.

4.4. Softness (stiffness) test

[0050] A test sample with a length of 75 mm and a width of 25 mm was knitted from the ultrafine functional fibers of Preparation Example 1. The test sample is subjected to the cantilever test in accordance with ASTM D1388-14 to measure the drape length. The results show that the drape length in the length direction is 5.3 mm, and in the width direction is 6.2 mm. The results indicate that the functional fibers of the present invention have excellent softness, making them particularly suitable for baby clothing or underwear.

[0051] The above embodiments are merely illustrative description of the principles and effects of the present invention and are intended to explain the inventive features of the present invention, not to limit the scope of protection of the present invention. Any modifications or arrangements easily accomplished by persons skilled in this field are within the scope claimed by the present invention. Therefore, the scope of protection of the present invention is defined by the appended claims.

Claims

1. A functional filament, comprising a polymer matrix and functional nanoparticles dispersed within the polymer matrix, wherein the functional filament has a cross-sectional diameter ranging from 1 μm to 30 μm , and the functional nanoparticles comprise element(s) selected from the group consisting of Au, Ag, Ti, Ge, Zn, Al, Mg, Si, Cu, Ca, Fe, Ba, K, Na, Mn, Ni, Ga, Pt, and combinations thereof.
2. The functional filament of claim 1, wherein the cross-sectional diameter of the functional filament ranges from 5 μm to 20 μm .
3. The functional filament of claim 1 or claim 2, wherein an average particle size of the functional nanoparticles ranges from 1 nm to 300 nm.
4. The functional filament of any one of claims 1 to 3, wherein the functional nanoparticles comprise Fe, Ti and Ca.
5. The functional filament of claim 4, wherein the functional nanoparticles further comprise element(s) selected from the group consisting of Al, Ba, Cu, Mg, Ni, Zn, Mn, and combinations thereof.

6. The functional filament of any one of claims 1 to 5, wherein the polymer matrix is selected from the group consisting of polyester, polyurethane (PU), poly(vinyl chloride) (PVC), polypropylene (PP), polyamide (PA), an amino-comprising polymer, silicone, and mixtures thereof.
7. The functional filament of claim 6, wherein the polymer matrix comprises polyester.
8. An ultrafine functional fiber, comprising the functional filament of any one of claims 1 to 7.
9. The ultrafine functional fiber of claim 8, wherein a fiber fineness of the ultrafine functional fiber is less than 0.7 denier.
10. A functional fabric, which is manufactured from a fiber material, wherein the fiber material comprises the ultrafine functional fiber of claim 8 or 9.

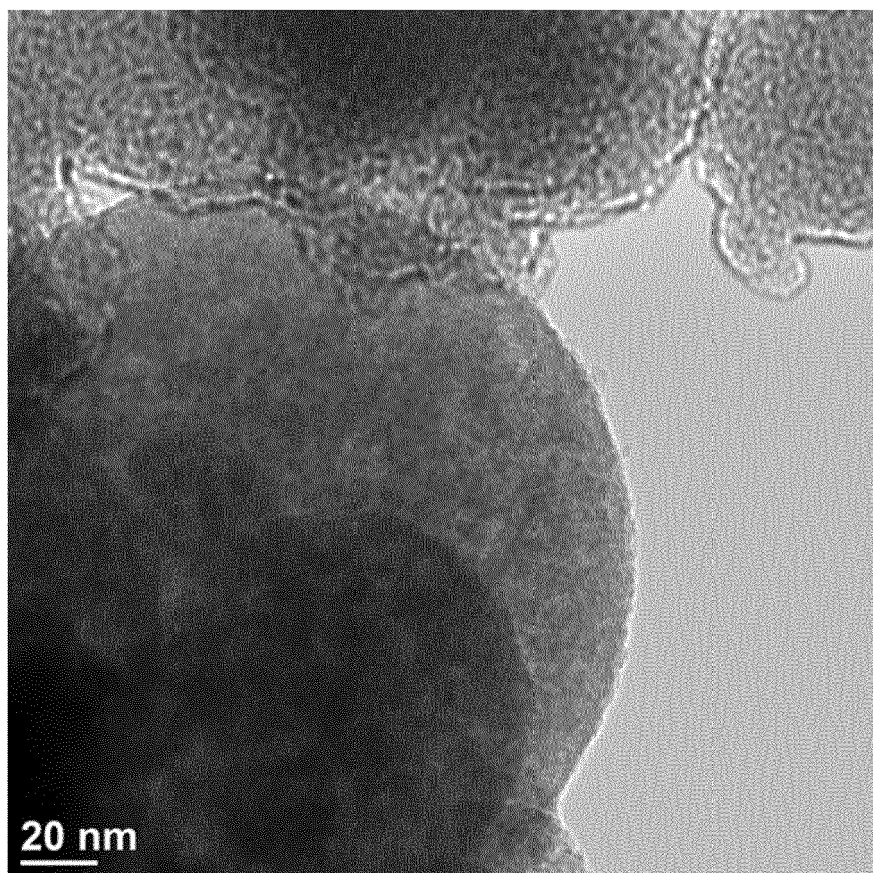


Fig. 1

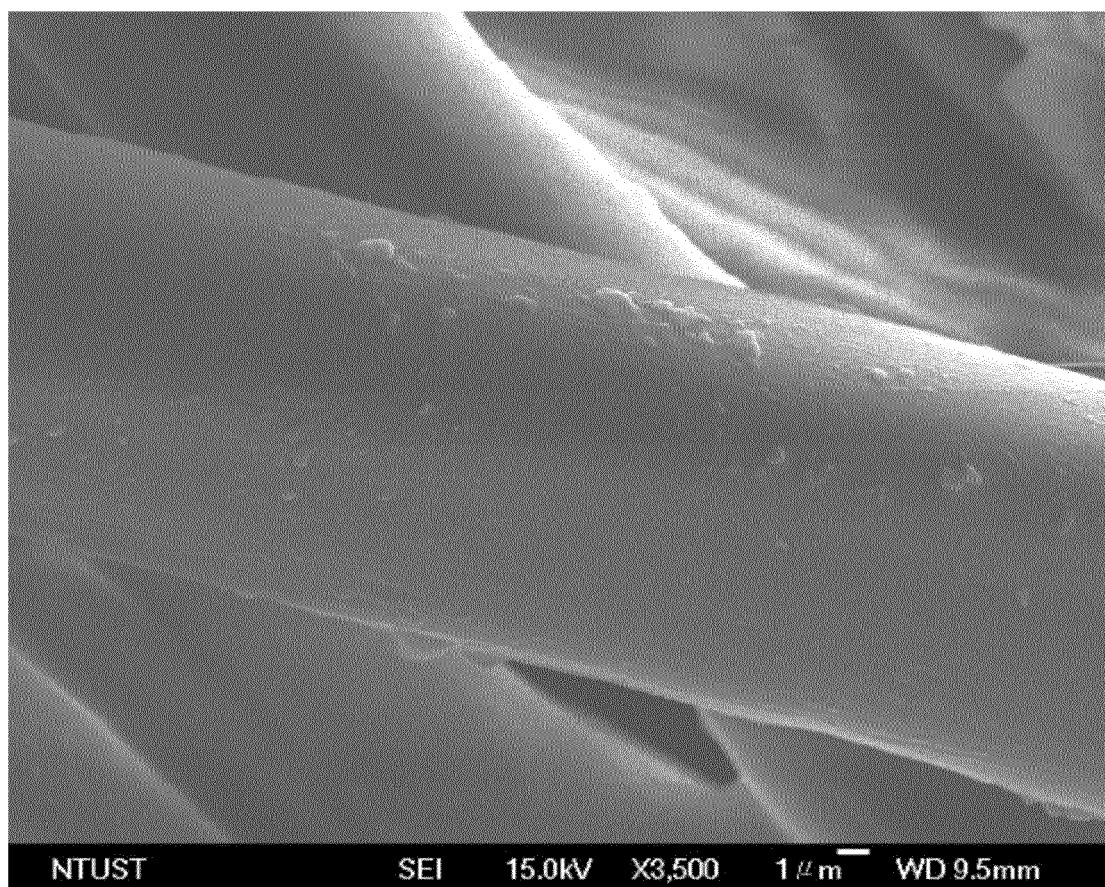


Fig. 2

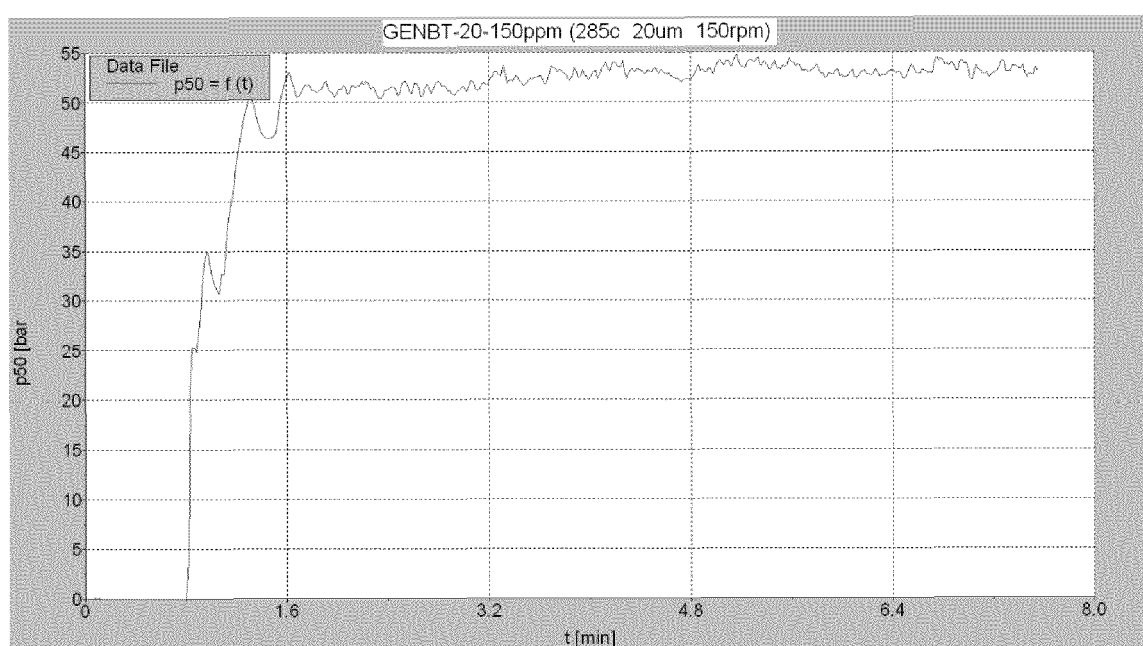


Fig. 3



EUROPEAN SEARCH REPORT

Application Number

EP 24 19 4856

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CN 112 779 629 A (NINGBO SANBANG MICROFIBER CO LTD) 11 May 2021 (2021-05-11)	1,8	INV. D01F1/10
Y	* paragraph [0010] - paragraph [0020] * -----	5	
X	US 2020/247961 A1 (FERRIS ANDREA [US] ET AL) 6 August 2020 (2020-08-06)	1,4,6,7	
Y	* paragraph [0065] * -----	5	
X	ABDELGHAFAR REHAB A. ET AL: "Surface coatings of polyester fabrics using titanium dioxide and zinc oxide for multifunctional medical applications", THE JOURNAL OF THE TEXTILE INSTITUTE, vol. 113, no. 12, 10 November 2021 (2021-11-10), pages 2621-2633, XP093257146, GB ISSN: 0040-5000, DOI: 10.1080/00405000.2021.2001892 * materials and methods, results and discussion section; figure 2; table 1 * -----	1-3,9,10	TECHNICAL FIELDS SEARCHED (IPC) D01F
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 7 March 2025	Examiner Massella, Daniele
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 24 19 4856

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 112779629 A	11-05-2021	NONE	
US 2020247961 A1	06-08-2020	AU 2019203685 B1	16-01-2020
		AU 2019203686 A1	16-01-2020
		AU 2019203687 A1	16-01-2020
		BR 112020026452 A2	23-03-2021
		BR 112020026461 A2	23-03-2021
		BR 112020026468 A2	23-03-2021
		CN 112714806 A	27-04-2021
		CN 112714807 A	27-04-2021
		CN 112739858 A	30-04-2021
		CO 2020016197 A2	10-12-2021
		CO 2020016199 A2	30-07-2021
		CO 2020016200 A2	30-07-2021
		EP 3814559 A1	05-05-2021
		EP 3814560 A1	05-05-2021
		EP 3814561 A1	05-05-2021
		IL 279743 A	01-03-2021
		IL 279744 A	01-03-2021
		IL 279746 A	01-03-2021
		JP 7432535 B2	16-02-2024
		JP 7432536 B2	16-02-2024
		JP 7489336 B2	23-05-2024
		JP 2021529864 A	04-11-2021
		JP 2021529896 A	04-11-2021
		JP 2021529897 A	04-11-2021
		KR 20210036344 A	02-04-2021
		KR 20210036345 A	02-04-2021
		KR 20210038883 A	08-04-2021
		RU 2767438 C1	17-03-2022
		TW 202001019 A	01-01-2020
		TW 202012521 A	01-04-2020
		TW 202012537 A	01-04-2020
		US 2019390020 A1	26-12-2019
		US 2020247961 A1	06-08-2020
		US 2020291194 A1	17-09-2020
		WO 2020005399 A1	02-01-2020
		WO 2020005400 A1	02-01-2020
		WO 2020005401 A1	02-01-2020
		ZA 202007747 B	29-06-2022
		ZA 202007748 B	30-03-2022
		ZA 202007749 B	27-07-2022

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82