

(19)



(11)

EP 3 495 538 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:

12.06.2019 Bulletin 2019/24

(51) Int Cl.:

D03D 15/00 (2006.01)

D03D 15/12 (2006.01)

D04B 1/16 (2006.01)

D06P 3/00 (2006.01)

(21) Application number: **17836922.9**

(86) International application number:

PCT/JP2017/027748

(22) Date of filing: **31.07.2017**

(87) International publication number:

WO 2018/025817 (08.02.2018 Gazette 2018/06)

(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 MK MT NL NO
PL PT RO RS SE SI SK SM TR**

Designated Extension States:

BA ME

Designated Validation States:

MA MD

• **ENDO, Ryohei**

Tokyo 100-8115 (JP)

• **WASHITAKE, Yosuke**

Kurashiki-shi

Okayama 713-8550 (JP)

• **IKEDA, Takayuki**

Kurashiki-shi

Okayama 713-8550 (JP)

(30) Priority: **05.08.2016 JP 2016154254**

(74) Representative: **Müller-Boré & Partner**

Patentanwälte PartG mbB

Friedenheimer Brücke 21

80639 München (DE)

(71) Applicant: **Kuraray Co., Ltd.**

Okayama 710-0801 (JP)

(72) Inventors:

• **TSUNOFURI, Shohei**

Tokyo 100-8115 (JP)

(54) **FLAME-RETARDANT FABRIC HAVING HIGH VISIBILITY**

(57) Provided is a flame-retardant fabric having a color that satisfies the criteria required by the international standard for high visibility ISO20471. The fabric includes polyetherimide-based fibers that contain a white pigment.

EP 3 495 538 A1

Description

FIELD OF THE INVENTION

5 **[0001]** The present invention relates to a flame-retardant fabric that can be obtained by dyeing flame-retardant polyetherimide-based fibers containing a white pigment, the flame-retardant fabric having a color that satisfies the criteria required by the international standard for high visibility ISO20471 and having an improved tenacity retention rate of fiber after dyeing.

10 BACKGROUND OF THE INVENTION

[0002] Polyetherimide-based fibers are excellent in heat resistance and flame retardancy, and are very effectively used in many applications, including the industrial material field, the electric and electronic field, the agricultural material field, the apparel field, the optical material field, and planes, automobiles and ships, etc.

15 **[0003]** In many applications with a central focus on the apparel field, not only polyetherimide-based fibers, but various highly-functional synthetic fibers are colored when they are used. In particular, there has been growing demand in applications to work clothing for outdoor construction sites, outdoor work related to car accidents or the like, traffic guidance, traffic control, etc. for fiber products, such as flame-retardant garments, with high visibility and excellent lightfastness, which are colored with fluorescent colors and others to ensure safety for the work.

20 **[0004]** Materials used in such highly visible fiber products are defined in accordance with the international standard for high visibility ISO20471. This standard specifies criteria for color properties of materials based on conditions known to this technical field, such as CIE chromaticity coordinates and luminosity coefficients.

[0005] As a material that is applicable to the above applications, Patent Document 1 discloses a flame-retardant fabric containing aramid, viscose or polyimide fibers which has high visibility by printing. However, this fabric exhibits colors

25 only in printed portions, not in the entire fabric.
[0006] Patent Document 2 describes a flame-retardant fabric containing polyetherimide-based fibers, which satisfies the conditions of chromaticity coordinates and luminosity coefficients specified by the European standard for high visibility EN471, which is equivalent to the international standard for high visibility ISO20471. However, in order to dye polyetherimide fibers to a color that satisfies the standard for high visibility, it is necessary to dye the polyetherimide fibers under
30 high-temperature and high-pressure conditions with a career that is a dyeing auxiliary. On this point, there is a problem that permeation of the dye and the career to the polyetherimide-based fibers while dyeing makes the fiber surface more prone to damage, leading to considerable deterioration in mechanical property of the fibers.

PRIOR ART DOCUMENT

35

PATENT DOCUMENT

[0007]

40

[Patent Document 1] JP Laid-open Patent Publication No. 2013-32612
[Patent Document 2] JP Laid-open Patent Publication No. 2014-237905

SUMMARY OF THE INVENTION

45 PROBLEMS TO BE SOLVED BY THE INVENTION

[0008] The object of the present invention is to provide a flame-retardant fabric that solves the above-mentioned problem, satisfies the international standard for high visibility ISO20471 and has an improved fiber tenacity retention rate.

50 MEANS FOR SOLVING THE PROBLEMS

[0009] As a result of intensive investigation of the problem, the inventors of the present invention found that dyeing procedure of flame retardant polyetherimide-based fibers in a condition that the fibers contain a white pigment achieves to obtain a flame-retardant fabric that is excellent in flame retardancy, has a color satisfying the criteria required by the
55 international standard for high visibility ISO20471 and has an improved retention rate of a fiber mechanical property, and the inventors thus achieved the present invention.

[0010] That is, the present invention is a flame-retardant fabric that includes polyetherimide-based fibers containing a white pigment and has a color satisfying the criteria required by the international standard for high visibility ISO20471.

[0011] Alternatively, the fabric after dyeing (dyed fabric) may have a color that has CIE chromaticity coordinates (x, y) within a color space delimited by (0.624, 0.374), (0.589, 0.366), (0.609, 0.343) and (0.655, 0.345), and a luminosity coefficient β equal to or greater than 0.40.

[0012] Alternatively, the fabric after dyeing may have a color that has CIE chromaticity coordinates (x, y) within a color space delimited by (0.450, 0.549), (0.420, 0.483), (0.375, 0.528) and (0.395, 0.602), and a luminosity coefficient β equal to or greater than 0.70.

[0013] Furthermore, the fabric may be a fabric that includes polyetherimide-based fibers having a fiber tenacity retention rate of 65% or higher.

[0014] Moreover, the present invention is a method for producing a polyetherimide-based fiber, the method including dyeing a polyetherimide-based fiber containing a white pigment at a temperature from 100°C to 125°C to give the fiber a color satisfying the criteria required by the international standard for high visibility ISO20471.

EFFECT OF THE INVENTION

[0015] The present invention can provide a flame-retardant fabric that satisfies the international standard for high visibility ISO20471 and has an improved fiber tenacity retention rate.

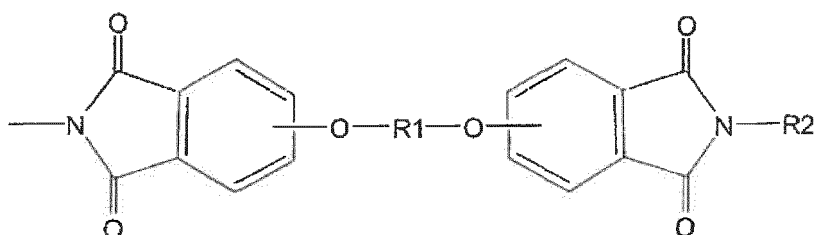
DESCRIPTION OF THE EMBODIMENTS

[0016] The present invention is characterized by that the flame-retardant fabric having a color satisfying the criteria required by the international standard for high visibility ISO20471 and an improved fiber tenacity retention rate. The flame-retardant fabric can be obtained by dyeing polyetherimide-based fibers having excellent flame retardancy wherein a white pigment is added to the fibers.

Polyetherimide-based Resin

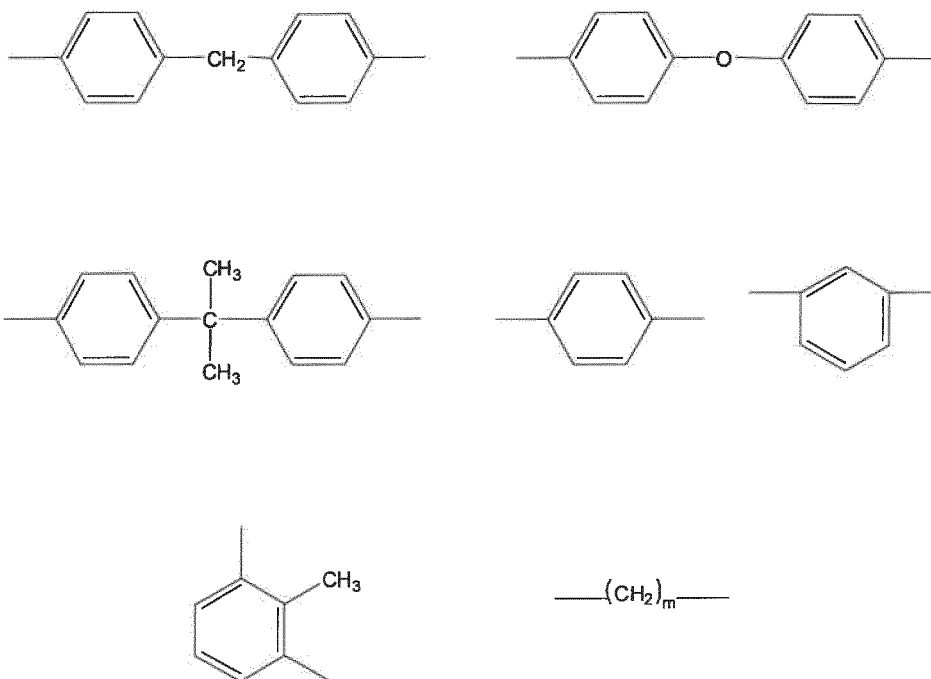
[0017] Examples of polyetherimide-based resins used in the present invention may include polymers containing a combination of repeating structural units represented by the following formula. In the formula, R1 represents a divalent aromatic residue having 6 to 30 carbon atoms, and R2 represents a divalent organic group selected from the group consisting of a divalent aromatic residue having 6 to 30 carbon atoms, an alkylene group having 2 to 20 carbon atoms, a cycloalkylene group having 2 to 20 carbon atoms, and a polydiorganosiloxane group in which the chain is terminated by an alkylene group having 2 to 8 carbon atoms.

[Chem. 1]



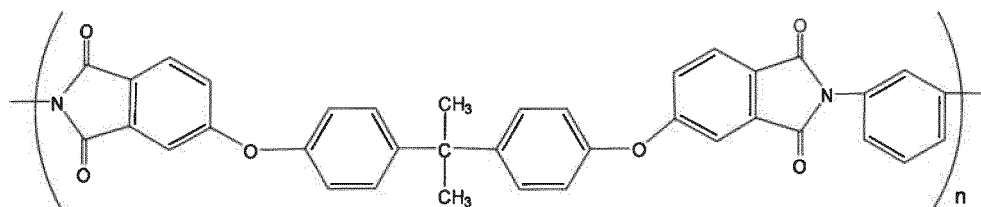
[0018] The preferable R1 and R2 include, for example, an aromatic residue and an alkylene group (e.g., m = 2 to 10) shown in the following formulae.

[Chem. 2]



[0019] In the present invention, from the viewpoint of an amorphous property, melt formability, and cost reduction, a preferable polymer includes a condensate of 2,2-bis[4-(2,3-dicarboxyphenoxy)phenyl]propane dianhydride and m-phenylenediamine, having a structural unit shown by the following formula as a main constituent. Such an amorphous polyetherimide is available from SABIC Innovative Plastics Holding under the trademark of "ULTEM".

[Chem. 3]



[0020] The polyetherimide-based resin used in the present invention preferably has a molecular weight distribution (Mw/Mn) smaller than 2.5. A molecular weight distribution equal to or greater than 2.5 may be not preferable because of poor spinnability.

White Pigment

[0021] The inventors have found that dyeing of a polyetherimide-based fiber containing, for example, 0.5 to 5.0% owf (on the weight of fiber) of, a white pigment enables to enhance luminosity required by the international standard for high visibility. A content less than 0.5% owf may be not preferable because the content of the white pigment dispersed in the fiber resin may be low to exhibit sufficient luminosity in the fiber after dyeing. A content greater than 5.0% owf may be not preferable because additives may be more likely to coagulate to decrease spinnability.

[0022] The white pigment used in the present invention may include anatase titanium oxide, rutile titanium oxide, zinc oxide, calcium carbonate, zirconium oxide, basic carbonate, and calcium sulfate dihydrate. The most preferable pigment is anatase titanium oxide, which has the highest reflectance rate at wavelengths in the visible region.

Dye

[0023] The dye used in the present invention may be any disperse dye as long as the dye is capable of dyeing a conventional polyester fiber and is not particularly limited. As the disperse dye particularly suitable for polyetherimide-

based fibers, there may be mentioned a disperse dye that has a good diffusion property, has a higher inorganic property in a ratio of inorganic/organic properties and typically contains hydroxyl group or a halogen atom. Examples of preferable dyes for polyetherimide-based fibers may include "Dianix Yellow AM-42," "Dianix Luminous Yellow GN" and "Dianix Luminous Yellow 10G" as yellow dyes; "Kayalon Brilliant Orange HL-SF200," "Reform Brilliant Orange CV-N" and "Dianix Orange AM-SLR" as orange dyes; and "Dianix Br. Scarlet SF" as a red dye. Some of the dyes mentioned above are capable of dyeing fibers successfully without a carrier. Use of a carrier makes it possible to achieve deep shade and also improved washfastness. In addition, the species of dyes to be used in the present invention is not particularly limited to the above-mentioned dyes because use of a carrier makes it possible to achieve successful dyeing with some of the dyes which do not achieve successful dyeing without a carrier.

Career

[0024] In the present invention, it is preferable to use a phthalimide compound, a benzyl alcohol compound, a chlorobenzene compound, a methylnaphthalene compound, or the like as a career. These careers may be singly used, or may be used in combination to make it possible to produce deeper shades. The following careers, for example, are commercially available: as a phthalimide career "Dye Career TN-55" (manufactured by DAIWA CHEMICAL INDUSTRIES Co., Ltd.); as a benzyl alcohol career "benzyl alcohol" (manufactured by Tokyo Chemical Industry Co., Ltd.); as a chlorobenzene career "IPC-71P Career C-71" (manufactured by Ipposha Oil Industries Co., Ltd.); and as a methylnaphthalene career "Tetrosin AT-M" (manufactured by Yamakawa Chemical Industry Co., Ltd.).

Color

[0025] The flame-retardant fabric of the present invention is characterized by having a color that satisfies the criteria required by the international standard for high visibility ISO20471. The international standard for high visibility ISO20471 specifies the criteria based on conditions such as CIE chromaticity coordinates and a CIE tristimulus value for each color type used in a material. That is, the standard requires a red material to have CIE chromaticity coordinates (x, y) within a color space delimited by (0.655, 0.345), (0.570, 0.340), (0.595, 0.315) and (0.690, 0.310), and a luminosity coefficient β equal to or greater than 0.25. Similarly, an orange-red material has to have CIE chromaticity coordinates within a color space delimited by (0.610, 0.390), (0.535, 0.375), (0.570, 0.340) and (0.655, 0.345), and a luminosity coefficient β equal to or greater than 0.40. A yellow material has to have CIE chromaticity coordinates within a color space delimited by (0.387, 0.610), (0.356, 0.494), (0.398, 0.452) and (0.460, 0.540), and a luminosity coefficient β equal to or greater than 0.70.

[0026] It is essential that fabric products in the condition immediately after dyeing satisfy the criteria required by the international standard for high visibility ISO20471 when the products are used for applications that require high visibility. In addition, it is preferable that materials are less susceptible to discoloration due to various environmental factors, e.g., light, or that materials still satisfy the criteria required by the international standard for high visibility ISO20471 even after discoloration occurs. Accordingly, if the flame-retardant fabric of the present invention is an orange-red material, the flame-retardant fabric after dyeing preferably has a color of CIE chromaticity coordinates (x, y) within a color space delimited by (0.624, 0.374), (0.589, 0.366), (0.609, 0.343) and (0.655, 0.345), and of a luminosity coefficient β equal to or greater than 0.40. The flame-retardant fabric of the present invention which is dyed to a color within the color space can have a chromaticity within the color space specified for an orange-red material by the international standard for high visibility ISO20471 even after the fabric is exposed to light.

[0027] Similarly, if the flame-retardant fabric of the present invention is a yellow material, the flame-retardant fabric after dyeing preferably has a color of CIE chromaticity coordinates (x, y) within a color space delimited by (0.450, 0.549), (0.420, 0.483), (0.375, 0.528) and (0.395, 0.602), and of a luminosity coefficient β equal to or greater than 0.70. The flame-retardant fabric of the present invention which is dyed to a color within the color space can have a chromaticity within the color space specified for a yellow material by the international standard for high visibility ISO20471 even after the fabric is exposed to light.

[0028] Furthermore, it is preferable in the present invention that a white pigment is uniformly dispersed in desired polyetherimide-based fibers. White pigment dispersed in the fibers enables light penetrating inside the dyed polyetherimide-based fibers to be scattered and reflected to the surface of the fiber, and thereby the white pigment allows the fibers to have a higher luminosity than that of fibers without white pigment. Thanks to the luminosity-enhancing effect, it is possible to dye fibers at a lower temperature than the dyeing temperature required in Patent Document 2, and thus, it is possible to obtain a flame-retardant fabric that has a luminosity satisfying the criteria required by the international standard for high visibility ISO20471 and is suppressed in deterioration in mechanical properties due to dyeing. The preferable range of dyeing temperatures is from 100°C to 125°C, and more preferably from 110°C to 120°C.

Method for Fiber Formation

[0029] Next, the method for forming fibers will be described. A fiber-formable resin is melt-extruded into a fibrous shape by using a single-screw or twin-screw extruder through a nozzle having a diameter of 0.1 to 10.0 mm. The resultant fiber is wound at a speed from 300 m/min to 3,000 m/min to produce a fiber of 0.1 to 1000 dtex.

Method for Adding White Pigment

[0030] Fibers containing a certain amount of a white pigment can be obtained by a method in which melt-spinning of a fiber-formable resin is carried out with adding a white pigment during melt-spinning procedure, or in which melt-spinning is carried out by using a fiber-formable resin containing white pigment that is added before melt-spinning. It is preferable to prepare a master batch by melt-mixing a resin and a white pigment so that the master batch and a fiber-formable resin are melt-knead in order to improve dispersibility of the white pigment.

Fabric

[0031] In the present invention, the polyetherimide-based fiber can be used to obtain a flame-retardant fabric with high visibility, that can be any type of fabric, including woven fabrics, knitted fabrics, and nonwoven fabrics.

Applications

[0032] The flame-retardant fabric of the present invention which satisfies the criteria required by the international standard for high visibility ISO20471 and is capable of having a tenacity retention rate equal to or greater than 65% can be applied to a wide range of applications that require flame retardancy and high visibility, such as protective clothing and/or accessories.

EXAMPLES

[0033] Hereinafter, the present invention will be more specifically explained with reference to examples. However, the present invention is not to be construed as being limited by these examples. It should be noted that flame resistance, chromaticity and luminosity, lightfastness and tenacity retention rates were evaluated in the following manners in the Examples described below.

Evaluation of Flame Resistance

[0034] In accordance with JIS K7201, samples each tied into a braid and having a length of 18 cm were prepared. After igniting the upper portion of the samples, the minimum oxygen concentration [limiting oxygen index (LOI) value] required for the samples to keep burning for at least 3 minutes or alternatively to be burned until the burning length of the sample reaches at least 5 cm was determined. The average of 3 samples (n = 3) was adopted.

Evaluation of Chromaticity and Luminosity

[0035] For each tubular knitted fabric after dyeing, the CIE chromaticity coordinates (x, y) and the luminosity coefficient β of reflected light were measured using "Spectrophotometer 3700d" manufactured by Minolta Co., Ltd. so as to evaluate chromaticity and luminosity.

Evaluation of Lightfastness

[0036] The xenon lamp irradiation test was performed using "7.5-kW Super Xenon Weather Meter SX75" manufactured by Suga Test Instruments Co., Ltd. in accordance with ISO105-B02. The xenon light fastness was determined by the 3rd exposure method of ISO105-B02: 1994. As for the orange-red color samples, light was irradiated until the blue standard fabric with level 5 reaches grade 3 of gray scale. As for the yellow color samples, light was irradiated until the blue standard fabric with level 4 reaches grade 4 of gray scale.

Evaluation of Tenacity Retention Rate

[0037] For each single fiber forming the tubular knitted fabric before and after dyeing, single fiber tenacity was measured by using an automatic tensile testing device for short fibers "AMS-C TENSILON/UTM-II-20" manufactured by Orientec

Co., Ltd., and the average of 10 samples (n = 10) was adopted. The fiber tenacity retention rate was calculated by the following formula.

$$\text{Fiber tenacity retention rate} = \frac{(\text{Average single fiber tenacity after dyeing})}{(\text{Average single fiber tenacity before dyeing})} \times 100(\%)$$

Example 1

[0038] "ULTEM 9011" manufactured by SABIC Innovative Plastics Holding (amorphous PEI system resin having a weight-average molecular weight (Mw) of 32,000, a number-average molecular weight (Mn) of 14,500 and a molecular weight distribution (Mw/Mn) of 2.2) was used as a polyetherimide resin. Hereinafter, the resin is abbreviated as "U-PEI resin." After kneading 95 parts by mass of the U-PEI resin and 5 parts by mass of the U-PEI master batch resin containing 10% owf of anatase titanium oxide relative to the U-PEI resin, the mixture was melt-extruded at 400°C, measured by a gear pump, and discharged through a nozzle having a hole diameter Φ of 0.2 mm, and then was wound at a speed of 1500 m/min to produce fibers of 84 dtex/24 f. Thus obtained fibers were formed into a tubular knitted fabric. The resultant tubular knitted fabric was placed in a sealable pressure-resistant stainless container together with the following dyeing solution containing dyes, a career and a UV absorber, etc. and then was dyed for 40 minutes at 115°C. The dyed tubular knitted fabric was subjected to reduction cleaning for 20 minutes at 80°C in a reduction cleaning bath as described below so as to remove impurities on the fiber surfaces.

Formulation and Liquid Volume of Dyeing Solution

[0039]

Tubular knitted fabric of polyether imide fibers: 10 g
 Ultra MT level [pH adjusting agent] (manufactured by Mitejima Chemical Co., Ltd.): 1 g/L
 Reform Brilliant Orange CV-N [orange dye] (manufactured by NIKKA FINE TECHNO CO., LTD.): 3.5% owf
 Dianix Luminous Yellow GN [yellow dye] (manufactured by DyStar Japan Ltd.): 0.5% owf
 TN-55 [career]: 4% owf
 Briand FOK-3 [ultraviolet absorber] (manufactured by Matsumoto Yushi-Seiyaku Co., Ltd.): 3% owf
 Total liquid volume: 200 cc
 Formulation of Reduced Cleaning Solution
 Sodium carbonate: 1 g/L
 Hydrosulfite: 1 g/L
 Amirajin D (manufactured by Dai-ichi Kogyo Seiyaku Co., Ltd.): 1 g/L
 Liquid volume: 200 cc

Example 2

[0040] After kneading 90 parts by mass of the U-PEI resin and 10 parts by mass of the U-PEI master batch resin containing 10% owf of anatase titanium oxide relative to the U-PEI resin, the mixture was melt-extruded at 400°C, measured by a gear pump, and discharged through a nozzle having a hole diameter Φ of 0.2 mm, and then was wound at a speed of 1500 m/min to produce fibers of 84 dtex/24 f. Thus obtained fibers were formed into a tubular knitted fabric. The resultant tubular knitted fabric was dyed and subjected to reduction cleaning under the same conditions as those of Example 1.

Example 3

[0041] After kneading 80 parts by mass of the U-PEI resin and 20 parts by mass of the U-PEI master batch resin containing 10% owf of anatase titanium oxide relative to the U-PEI resin, the mixture was melt-extruded at 400°C, measured by a gear pump, and discharged through a nozzle having a hole diameter Φ of 0.2 mm, and then was wound at a speed of 1500 m/min to produce fibers of 84 dtex/24 f. Thus obtained fibers were formed into a tubular knitted fabric. The resultant tubular knitted fabric was dyed and subjected to reduction cleaning under the same conditions as those of Example 1.

Example 4

[0042] After kneading 50 parts by mass of the U-PEI resin and 50 parts by mass of the U-PEI master batch resin containing 10% owf of anatase titanium oxide relative to the U-PEI resin, the mixture was melt-extruded at 400°C, measured by a gear pump, and discharged through a nozzle having a hole diameter Φ of 0.2 mm, and then was wound at a speed of 1500 m/min to produce fibers of 84 dtex/24 f. Thus obtained fibers were formed into a tubular knitted fabric. The resultant tubular knitted fabric was dyed and subjected to reduction cleaning under the same conditions as those of Example 1.

Example 5

[0043] After kneading 90 parts by mass of the U-PEI resin and 10 parts by mass of the U-PEI master batch resin containing 10% owf of zinc oxide relative to the U-PEI resin, the polyetherimide resin containing zinc oxide whose content was adjusted to 0.5% by weight was melt-extruded at 400°C, measured by a gear pump, and discharged through a nozzle having a hole diameter Φ of 0.2 mm, and then was wound at a speed of 1500 m/min to produce fibers of 84 dtex/24 f. Thus obtained fibers were formed into a tubular knitted fabric. The resultant tubular knitted fabric was dyed and subjected to reduction cleaning under the same conditions as those of Example 1.

Example 6

[0044] A tubular knitted fabric was prepared in the same conditions as those of Example 2 and was dyed under the same conditions as those of Example 2, except that the dye was changed to Dianix Luminous Yellow GN (1.0% owf).

Comparative Example 1

[0045] The U-PEI resin was independently melt-extruded at 400°C, measured by a gear pump, and discharged through a nozzle having a hole diameter Φ of 0.2 mm, and then was wound at a speed of 1500 m/min to produce fibers of 84 dtex/24 f. Thus obtained fibers were formed into a tubular knitted fabric. The resultant tubular knitted fabric was dyed and subjected to reduction cleaning under the same conditions as those of Example 1.

Comparative Example 2

[0046] A tubular knitted fabric prepared under the same conditions as those of Comparative Example 1 was placed in a sealable pressure-resistant stainless container together with a dyeing solution containing the same dyes, career and UV absorber, etc. to those of Example 1 and was dyed for 40 minutes at 135°C. The dyed tubular knitted fabric was subjected to reduction cleaning for 20 minutes at 80°C in a reduction cleaning bath as described above so as to remove impurities on the fiber surfaces.

Comparative Example 3

[0047] A tubular knitted fabric prepared under the same conditions as those of Comparative Example 1 was placed in a sealable pressure-resistant stainless container together with a dyeing solution containing the same dye, career and UV absorber, etc. as those of Example 6 and was dyed for 40 minutes at 135°C. The dyed tubular knitted fabric was subjected to reduction cleaning for 20 minutes at 80°C in a reduction cleaning bath as described above so as to remove impurities on the fiber surfaces.

[Table 1]

	White pigment	Addition amount (% owf)	Orange dye (% owf)	Yellow dye (% owf)	Dyeing temp. (°C)	Dye color	LOI	Tenacity retention rate (%)	After dyeing			After lightfastness evaluation		
									x	y	Luminosity coef. β	x	y	Luminosity coef. β
Example 1	Titanium oxide	0.5	3.5	0.5	115	Orange-red	32	67.8	0.601	0.360	0.428	0.558	0.373	0.448
Example 2	Titanium oxide	1.0	3.5	0.5	115	Orange-red	32	67.5	0.604	0.359	0.430	0.561	0.372	0.450
Example 3	Titanium oxide	2.0	3.5	0.5	115	Orange-red	33	67.2	0.602	0.360	0.444	0.559	0.373	0.464
Example 4	Titanium oxide	5.0	3.5	0.5	115	Orange-red	32	65.6	0.595	0.361	0.452	0.547	0.374	0.472
Example 5	Zinc oxide	1.0	3.5	0.5	115	Orange-red	32	67.0	0.594	0.365	0.423	0.547	0.363	0.443
Example 6	Titanium oxide	1.0	-	1.0	115	Yellow	32	67.8	0.406	0.540	0.910	0.402	0.524	0.830
Comparative Example 1	-	-	3.5	0.5	115	Orange-red	32	76.8	0.585	0.360	0.384	0.542	0.373	0.429
Comparative Example 2	-	-	3.5	0.5	135	Orange-red	32	48.3	0.600	0.358	0.422	0.556	0.371	0.442
Comparative Example 3	-	-	-	1.0	135	Yellow	32	49.7	0.438	0.525	0.730	0.421	0.511	0.764

[0048] Table 1 shows the evaluation results for the tubular knitted fabrics obtained in Examples 1-6 and Comparative Examples 1-3. The tubular knitted fabrics of Examples 1-6 were evaluated as having flame retardancy, being high in fiber tenacity retention rate, and having colors that satisfied the criteria required by the international standard for high visibility ISO20471 after dyeing as well as after the lightfastness evaluation. The tubular knitted fabric of Comparative Example 1 was evaluated as not having a color that satisfied the criteria required by the international standard for high visibility ISO20471 after dyeing because the polyetherimide-based fiber without white pigment was dyed at 115°C. The tubular knitted fabrics of Comparative Examples 2 and 3 were evaluated as having low tenacity retention rates of the polyetherimide-based fibers constituting the fabrics because the polyetherimide-based fibers without white pigment were dyed at 135°C.

INDUSTRIAL APPLICABILITY

[0049] The flame-retardant fabric according to the present invention which contains polyetherimide-based fibers with at least one additive selected from a group consisting of white pigments at a certain amount has high luminosity. Therefore, the fabric can be used as highly visible protective clothing and/or accessories that require flame retardancy and, thus, is industrially applicable in the fields of manufacturing and/or processing the fibers.

[0050] The preferred embodiments according to the present invention have been described above, but those skilled in the art would readily conceive of various changes and modifications within the obvious range in view of the present specification. Accordingly, such changes and modifications are construed as within the scope of the invention as defined from the scope of the claims.

Claims

1. A flame-retardant fabric comprising polyetherimide-based fibers containing a white pigment, the fabric having a color that satisfies the criteria required by the international standard for high visibility ISO20471.
2. The flame-retardant fabric according to claim 1, wherein the fabric after dyeing has a color that has CIE chromaticity coordinates (x, y) within a color space delimited by (0.624, 0.374), (0.589, 0.366), (0.609, 0.343) and (0.655, 0.345), and a luminosity coefficient β equal to or greater than 0.40.
3. The flame-retardant fabric according to claim 1, wherein the fabric after dyeing has a color that has CIE chromaticity coordinates (x, y) within a color space delimited by (0.450, 0.549), (0.420, 0.483), (0.375, 0.528) and (0.395, 0.602), and a luminosity coefficient β equal to or greater than 0.70.
4. The flame-retardant fabric according to any one of claims 1 to 3, wherein the fabric comprises polyetherimide-based fibers having a fiber tenacity retention rate of 65% or higher.
5. A method for producing a polyetherimide-based fiber, the method comprising dyeing a polyetherimide-based fiber containing a white pigment at a temperature from 100°C to 125°C to give the fiber a color that satisfies the criteria required by the international standard for high visibility ISO20471.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/027748

A. CLASSIFICATION OF SUBJECT MATTER

D03D15/00(2006.01)i, D03D15/12(2006.01)i, D04B1/16(2006.01)i, D06P3/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

D01F1/00-6/96, D01F9/00-9/04, D03D1/00-27/18, D04B1/00-39/08

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017

Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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	JP 2014-237905 A (Kuraray Co., Ltd.),	1-3
Y	18 December 2014 (18.12.2014), paragraphs [0034], [0042] (Family: none)	4, 5
Y	JP 2014-234576 A (Kuraray Co., Ltd.), 15 December 2014 (15.12.2014), claims; paragraph [0023] (Family: none)	4, 5
A	JP 2015-168908 A (Kuraray Co., Ltd.), 28 September 2015 (28.09.2015), (Family: none)	1-5
A	JP 2011-196003 A (Kuraray Co., Ltd.), 06 October 2011 (06.10.2011), (Family: none)	1-5

☒ 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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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
03 October 2017 (03.10.17)Date of mailing of the international search report
17 October 2017 (17.10.17)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/JP2017/027748

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 02-099674 A (Teijin Ltd.), 11 April 1990 (11.04.1990), (Family: none)	1-5

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2013032612 A [0007]
- JP 2014237905 A [0007]