

(19)



(11)

EP 3 245 320 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
06.05.2020 Bulletin 2020/19

(51) Int Cl.:
D03D 1/00 (2006.01) D03D 15/00 (2006.01)
D03D 15/12 (2006.01)

(21) Application number: **16703639.1**

(86) International application number:
PCT/US2016/012586

(22) Date of filing: **08.01.2016**

(87) International publication number:
WO 2016/114984 (21.07.2016 Gazette 2016/29)

(54) **FLAME RESISTANT FABRIC**

FLAMMWIDRIGER STOFF

TISSU ININFLAMMABLE

(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

- **BARNES, Todd, C.**
Kingston, Ontario, K7M 8W1 (CA)
- **GREEN, David, Anthony**
Marietta, GA 30064 (US)

(30) Priority: **12.01.2015 US 201562102332 P**

(74) Representative: **Michalski Hüttermann & Partner**
Patentanwälte mbB
Speditionstraße 21
40221 Düsseldorf (DE)

(43) Date of publication of application:
22.11.2017 Bulletin 2017/47

(73) Proprietor: **INVISTA Textiles (U.K.) Limited**
Manchester M2 3DE (GB)

(56) References cited:
WO-A2-2011/050257 US-A- 5 763 103
US-A1- 2006 292 953

(72) Inventors:
• **GUO, Chuanpu**
Marietta, GA 30066 (US)

EP 3 245 320 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description**Field of Invention**

- 5 **[0001]** The present disclosure relates to flame resistant fabrics made from yarns comprising cellulose fiber, polyamide fiber, and oxidized polymeric biregional fiber.

Background

- 10 **[0002]** Flame resistant garments are worn by workers exposed to thermal and flame hazards in the workplace such as heat, open flame, and electric arc flash to reduce potential bodily injuries.
- [0003]** Many flame resistant garments are made with 88/12 fabrics comprising a blend of 88% cotton fibers and 12% nylon fibers. The fabrics are typically treated with phosphorous-based flame retardant chemicals. The fabrics meet the industrial standards of flammability performance requirements. Further, because the majority of the fabric comprises
- 15 cotton fibers, the fabrics are relatively inexpensive. In addition, these fabrics are more durable during industrial laundering and wearing as compared to 100% cotton fabrics since addition of nylon fibers to the fabric provides a significant improvement in abrasion resistance of the fabrics. The 88/12 fabrics are commercially available at a weight of approximately 220.4-0237.34 g/m² or more. One example of an 88/12 fabric is UltraSofot® fabric produced by Westex Inc, an entity of Miliken and Co.
- 20 **[0004]** There has been a continuing need from end-users, however, for inexpensive, flame retardant fabrics weighing less than 220.4 g/m² that are still durable for industrial laundering and wearing. Currently, 88/12 fabrics at a weight less than 220.4 g/m² exhibit deficiencies in meeting industrial flammability standards.
- [0005]** In order to meet these standards, inherently flame resistant fibers such as meta-aramid fibers, commercially marketed as Nomex® fibers by Dupont Company, are used for light weight flame retardant fabrics.
- 25 **[0006]** U.S. Patent 6,358,608 discloses fire retardant and heat resistant yarns, fabrics, felts and other fibrous blends which incorporate up to 99.9% oxidized polyacrylonitrile fibers together with at least additional fiber such as p-aramid.
- [0007]** Published U.S. Patent Application No. 2011/0165397 discloses stitch bonded flame resistant fabrics comprising partially oxidized polyacrylonitrile fibers and/or yarns.
- [0008]** Published U.S. Patent Application No. 2011/0239618 discloses a fire retardant fabric manufactured from oxidized polyacrylonitrile fibers having a fineness of about 0.5 to about 1.5 denier per fiber.
- 30 **[0009]** Published U.S. Patent Application No. 2014/0047625 discloses clothing and fabric made from oxidized polyacrylonitrile or other high limiting oxygen index materials in which the yarn strands are encapsulated or coated with a water shedding silicone polymer or other water-shedding material.
- [0010]** However, the fabrics described in the above-mentioned references are expensive, and are uncomfortable to wear.
- 35 **[0011]** WO 2010/135214 discloses flame resistant fabrics made from a blend of lyocell fibers and flame resistant fibers such as flame resistant (FR) cotton and FR treated rayon.
- [0012]** WO 2011/050257 discloses a blended yarn and fabric comprising from 10% to 85% by weight of an oxidized polymeric biregional fiber, such as an oxidized polyacrylonitrile fiber. The disclosed yarn is blended with at least one synthetic fiber from the group consisting of FR rayon, FR treated cellulose, *m*-aramid, *p*-aramid, modacrylic, novoloid, melamine, wool, nylon, regenerated cellulose, polyvinyl chloride, antistatic fiber, poly(*p*-phenylenebenzobisoxazole) (PBO), polybenzimidazole (PBI), and polysulphonamide (PSA).
- 40 **[0013]** Thus, there is a need for lightweight flame resistant fabrics that are durable for industrial laundering, comfortable for wearing, affordable for end users, and in compliance with industrial standards such as are described in NFPA 70E ("Standard for Electrical Safety in the Workplace") and NFPA 2112 ("Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire").
- 45

Summary of the Invention

- 50 **[0014]** An aspect of the present invention relates to a fabric comprising 20 to 90 percent by weight of natural cellulose fiber; 3 to 45 percent by weight of polyamide fiber; 5 to 35 percent by weight of biregional fiber comprising an oxidized polymer selected from the group consisting of acrylonitrile-based homopolymers, acrylonitrile-based copolymers, acrylonitrile-based terpolymers, and combinations thereof; and 1 to 20 percent by weight of FR rayon fiber.
- [0015]** In one nonlimiting embodiment, the fabric has a basis weight of from 101.7 g/m² to 508.6 g/m².
- 55 **[0016]** In one nonlimiting embodiment, the fabric is treated with flame retardant chemistry.
- [0017]** In one nonlimiting embodiment, the fabric has an arc thermal performance value of 33.5 J/cm² or greater.
- [0018]** In one nonlimiting embodiment, the fabric has a ratio of arc thermal performance value to basis weight of 1.24 or greater.

[0019] In one nonlimiting embodiment, the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise the biregional fibers.

[0020] Another embodiment of the current invention relates to a fabric comprising 20 to 90 percent by weight of natural cellulose fiber, 3 to 45 percent by weight of polyamide fiber, 1 to 9 percent by weight of *para*-aramid fiber, 1 to 20 percent by weight of FR rayon fiber and 5 to 35 percent by weight of biregional fiber comprising an oxidized polymer selected from the group consisting of acrylonitrile-based homopolymers, acrylonitrile-based copolymers, acrylonitrile-based terpolymers, and combinations thereof, wherein the fabric has a basis weight of from 101.7 g/m² to 508.6 g/m², and wherein the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise the majority of the FR rayon, *para*-aramid and the biregional fibers.

Detailed Description of the Invention

[0021] Provided by this disclosure are light-weight, inexpensive, flame resistant fabrics made from yarns comprising fiber from 20% to 90% by weight of natural cellulose fiber, 3% to 45% by weight of polyamide fiber, and 5% to 35% by weight of oxidized polymeric biregional fiber. All numerical values recited herein are understood to be modified by the term "about".

[0022] Sufficient natural cellulose fibers from 20% to 90% by weight are used in these fabrics to improve the comfort properties of fabric and reduce material cost. Cellulose fiber refers to cotton fibers, other natural cellulose fibers and synthetic cellulosic fibers. Synthetic cellulosic fibers include, but are not limited to rayon and lyocell. In some preferred embodiments the cellulose fiber is cotton fiber. Additional examples of cellulose fibers useful in these fabrics include, but are not limited to, linen, hemp, bamboo, rayon and jute.

[0023] Polyamide fibers from 3% to 45% by weight are included in the yarns to impart a durability to the fabrics similar to, or better than, 88/12 fabrics. Suitable polyamides include, but are not limited to, nylon 6,6; nylon 6; nylon 4,6; nylon 6,12; nylon 6,10; nylon 6T; nylon 61; nylon 9T; nylon DT (where D = Dytek® A diamine, 2-methyl-1,5-diaminopentane); nylon DI; nylon D6; nylon 7; nylon 11; nylon 12; nylon MXD-6 and/or combinations thereof. By "combinations thereof" with respect to polyamides, it is meant to include, but is not limited to, block copolymers, random copolymers, terpolymers, as well as melt blends. In some preferred embodiments the polyamide fiber is nylon 6,6 fiber.

[0024] Fabrics of this disclosure further comprise 5% to 35% by weight of oxidized polymeric biregional fiber. The oxidized polymeric biregional fiber includes the oxidized fibers formed from rayon based fibers, pitch based fibers and fibers formed from polymers selected from the group comprising acrylonitrile-based homopolymers, acrylonitrile-based copolymers, acrylonitrile-based terpolymers and combinations thereof. In some nonlimiting embodiments an oxidized polyacrylonitrile fiber is used. Examples of oxidized polymeric biregional fibers useful in these fabrics are set forth in WO 2011/050257 A2. In one embodiment, inherent flame resistant oxidized polyacrylonitrile fibers from 5% to 35% by weight are used as the oxidized polymeric biregional fiber to provide these fabrics with superior heat, flame, and electric arc flash protection performance.

[0025] Fabrics containing the disclosed blend of fibers are durable, comfortable, inexpensive, and flame resistant.

[0026] In one nonlimiting embodiment, the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise the biregional fibers. The inventors have discovered that it is advantageous to ensure that a majority of polyamide fibers are in the warp yarns so that they are distributed on the surface size of twill or sateen fabrics, while a majority of the biregional fibers are in the filling direction so that they are on the back side of the fabrics. This is because the biregional fibers may not be dyeable and can remain hidden, which improves the durability, appearance and applicability of the fabric.

[0027] In one nonlimiting embodiment, the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise 50 to 100 percent by weight of the biregional fibers in the fabric.

[0028] In another nonlimiting embodiment, the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise at least 75 percent by weight of the biregional fibers in the fabric.

[0029] In yet another nonlimiting embodiment, the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise 100 percent by weight of the biregional fibers in the fabric.

[0030] In one nonlimiting embodiment, the fabric further comprises from 1 to 9 percent by weight of *para*-aramid fiber. In another nonlimiting embodiment, the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise from 50 to 100 percent by weight of the *para*-aramid and the biregional fibers. In yet another nonlimiting embodiment, the fabric comprises warp yarns and filling yarns, wherein the filling yarns comprise from 100 percent by weight of the *para*-aramid fibers and the biregional fibers.

[0031] The fabric further comprises from 1 to 20 percent by weight of FR rayon fiber. In another nonlimiting embodiment, the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise from 50 to 100 percent by weight of the FR rayon fibers and the biregional fibers. In yet another nonlimiting embodiment, the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise from 100 percent by weight of the FR rayon fibers and the biregional fibers.

[0032] In one nonlimiting embodiment, the fabric further comprises from 1 to 9 percent by weight of *para*-aramid fiber and from 1 to 20 percent by weight of FR rayon fiber. In another nonlimiting embodiment, the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise from 50 to 100 percent by weight of the FR rayon fibers, the *para*-aramid fibers and the biregional fibers. In yet another nonlimiting embodiment, the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise from 100 percent by weight of the FR rayon fibers, the *para*-aramid fibers and the biregional fibers.

[0033] Further, fabrics made in accordance with this disclosure are light weight and durable for the industrial laundering and wearing. In one embodiment, the weight of the fabric is from 101.7 g/m² to 508.6 g/m². In one embodiment, the weight of the fabric is less than 220.4 g/m², for example, from 101.7 g/m² to 220.4 g/m².

[0034] Another aspect of the current invention relates to a fabric comprising 20 to 90 percent by weight of cellulose fiber, 3 to 45 percent by weight of polyamide fiber, 1 to 9 percent by weight of *para*-aramid fiber, 1 to 20 percent by weight of FR rayon fiber and 5 to 35 percent by weight of biregional fiber comprising an oxidized polymer selected from the group consisting of acrylonitrile-based homopolymers, acrylonitrile-based copolymers, acrylonitrile-based terpolymers, and combinations thereof, wherein the fabric has a basis weight of from 101.7 g/m² to 508.6 g/m², and wherein the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise the majority of the FR rayon, *para*-aramid and the biregional fibers.

[0035] In nonlimiting embodiment of this aspect, the filling yarns comprise from 100 percent by weight of the FR rayon fibers, the *para*-aramid fibers and the biregional fibers.

[0036] Fabrics produced in accordance with this disclosure include, but are not limited to, knitted, woven, and nonwoven fabrics having the fiber blend disclosed herein and can be used to make various flame resistant garments for heat, flame, electric arc flash protection applications. The woven construction may include, but is not limited to, plain, basket, twill, satin or sateen weave as well as a more durable ripstop weave. In some embodiments, the fabrics can be formed with yarns produced by the various types of spinning technologies such as, but not limited to, ring spinning, open-end (OE), air jet, Vortex, core spun, and others.

[0037] The fabrics, in some embodiments, can be dyed by commercially available dye methods.

[0038] Further, in some embodiments, fabrics produced in accordance with this disclosure are treated with phosphorous-based flame retardant chemicals and/or other flame retardant chemicals. In one nonlimiting embodiment, the fabric is treated by phosphorous-based flame retardant chemicals in the presence of urea/ammonia.

[0039] These fabrics provide superior flame and thermal protection performance for flame resistant applications in accordance with the industrial standard test methods. The fabrics, in some embodiments at a light weight of 220.4 g/m² or even lower such as less than 203.4 g/m², have an arc rating of 8.0 or greater, which meets or exceeds the performance requirement in arc rating according to ASTM F1959, "Standard Test Method for Determining the Arc Rating of Materials for Clothing." The fabrics at 220.4 g/m² have a ratio of arc rating (Arc thermal performance value) to fabric weight of 1.24 or higher, while the fabrics at a weight less than 203.4 g/m² have a ratio of arc rating (Arc thermal performance value) to fabric weight of 1.36 or higher. Fabrics with high ratio of arc rating to fabric weight of 1.24 to 1.36 or even greater provide wearers of garments a comfortable protective garment with superior electric arc flash protection performance. The fabrics of some embodiments at light weight of 220.4 g/m² or even lower such as less than 203.4 g/m² meet or exceed performance requirements for flash fire protection applications in accordance with National Fire Protection Association Standard (NFPA) 2112 (2012), "Standard on Flame-Resistance Garments for Protection of Industrial Personnel Against Flash Fire." Further, the light weight fabrics of this disclosure have been demonstrated to have a char length less than 10.16 cm in a vertical flammability test according to the ASTM D6413: Standard Test Method for Flame Resistance of Textiles (Vertical Test). In addition, the fabrics of this disclosure were demonstrated to have a heat transfer performance (HTP) rating greater than 33.5 J/cm² per the NFPA 2112: (National Fire Protection Association) Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire. Section 8.2 (Heat Transfer Performance) and an average predicted body burn less than 50 percent per the ASTM F1930: Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin. Thus, the light weight fabrics of this disclosure fabrics meet both the performance requirements on the electric arc rating for HRC level II in NFPA standard 70 E (2012) and the performance requirements on the flash fire protection in the NFPA 2112 (2012) standard. Further, some embodiments of these light weight fabrics can be dual certified fabrics for both the NFPA 70E HRC level II and NFPA 2112 (2012).

[0040] Also disclosed are articles formed from fabrics of the current disclosure. In some embodiments, the articles include, but are not limited to apparel, shirts, pants, jackets and coveralls.

[0041] The following section provides further illustration of the fabrics of this invention. These working examples are illustrative only and are not intended to limit the scope of the invention in any way.

EXAMPLES

Example 1: Fabrics and Yarn Samples

[0042] Table 1 lists multiple fabric and yarn samples. Fabric sample 1 is an embodiment of the current invention. Fabric samples 2 and 3 are comparative examples. All three fabric samples were woven fabrics having a twill construction. Fabric sample 1 was woven with yarns comprising 47 weight % natural cellulose fiber, 14 weight % FR rayon fiber, 16 weight % polyamide fiber, 6 weight % para-aramid fiber, and 17 weight % oxidized polymeric biregional fiber. Fabric sample 1 comprised warp yarns comprising the natural cellulosic fibers and the polyamide fibers, and filling yarns comprising the FR rayon fibers, the polyamide fibers, the para-aramid fibers and the biregional fibers. In this way, a large portion of polyamide fibers were distributed on the surface size of twill fabrics, while many oxidized biregional polyacrylonitrile fibers and *para*-aramid fibers that were not dyeable were hidden on the back side of twill fabrics. As a result, durability and appearance of the fabrics was substantially improved.

[0043] Fabric sample 2 is a baseline fabric for comparison with fabric sample 1. Fabric sample 2 was woven with the same filling yarns, but different warp yarns when compared to fabric sample 1. Fabric sample 2 comprised 35 weight % FR rayon fiber, 2 weight % polyamide fiber, 15 weight % *para*-aramid fiber, 29 weight % modacrylic fiber and 19 weight % oxidized polymeric biregional fiber.

[0044] Fabric sample 3 is another baseline fabric for comparison with fabric sample 1. Fabric sample 3 was woven with the same warp yarns and different filling yarns when compared to fabric sample 1. Fabric sample 3 comprised 88 weight % cotton fiber and 12 weight % polyamide fiber.

Table 1. Fabrics and Yarns

Fabric Sample	1	2	3
Fabric weight (g/m ²)	244.1	264.5	237.3
Fabric composition by weight %	47% cotton 14% FR rayon 16% polyamide 17% oxidized biregional polyacrylonitrile 6% <i>para</i> -aramid	35% FR rayon 2% polyamide 19% oxidized biregional polyacrylonitrile 15% <i>para</i> -aramid 29% modacrylic	88% cotton 12% polyamide
Fiber components in warp yarns	cotton polyamide	FR rayon <i>Para</i> -aramid Modacrylic	cotton polyamide
Fiber components in filling yarns	oxidized biregional polyacrylonitrile <i>para</i> -aramid polyamide FR rayon	oxidized biregional polyacrylonitrile <i>para</i> -aramid polyamide FR rayon	cotton
Weaving style	twill	twill	twill

Example 2

Test Methods

[0045] Test methods used to evaluate fabrics of the present invention included:

ASTM D6413: Standard Test Method for Flame Resistance of Textiles (Vertical Test);

NFPA 2112 (2012): (National Fire Protection Association) Standard on Flame-Resistant, Garments for Protection of Industrial Personnel Against Flash Fire. Section 8.2 (Heat Transfer Performance);

NFPA 2112 (2012): (National Fire Protection Association) Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire. Section 8.4 (Thermal Shrinkage Resistance);

ASTM F1930: Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin;

EP 3 245 320 B1

ASTM F1959: Standard Test Method for Determining the Arc Rating of Materials for Clothing; and

NFPA 70E (2012): Standard for Electrical Safety in the Workplace

[0046] The term HTP, as used herein, refers to Heat Transfer Performance.

[0047] The term ATPV, as used herein, refers to Arc Thermal Performance value.

[0048] Table 2 lists test results for fabric samples of Example 1.

Table 2 Test Results, NFPA 70E and NFPA 2112

	Fabric #1	Fabric #2	Fabric #3
Fabric weight after 3X home launderings (g/m ²)	250.9	271.3	264.5
ATPV (J/cm ²)	53.1	40.6	40.2
Ratio of ATPV to fabric weight	1.72	1.21	1.23
Char length, warp (cm)	7.37	< 10.16	8.89
Char length, fill (cm)	7.87	< 10.16	8.89
After flame, warp (sec.)	0	< 2.0	0
After flame, fill (sec.)	0	< 2.0	0
HTP (J/cm ²), space	38.5	> 33.5	41.8
Thermal shrinkage%, warp	3.6	< 10.0	< 10.0
Thermal shrinkage%, fill	3.3	< 10.0	< 10.0
Predicted body burn% in Manikin test	< 50	< 50.0	< 50.0

[0049] All the fabric samples met or exceeded performance requirements for the intended end use applications in accordance with NFPA 70E and NFPA 2112.

[0050] Fabric sample 1 was woven with the same filling yarns and different warp yarns with fabric sample 2. Fabric sample 1 was made with more cellulose fibers, including additional cotton fibers and less *para*-aramid fibers than fabric sample 2. The ratio of ATPV to fabric weight of fabric sample 1 (1.72) was much higher than that determined for fabric sample 2 (1.21). Fabric sample 1 is woven with the same warp yarns and different filling yarns with fabric sample 3. About 17% by weight oxidized biregional polyacrylonitrile fibers were included in fabric sample 1, which resulted in the higher ratio of ATPV to fabric weight of fabric sample 1 (1.72) than was determined for fabric sample 3 (1.23). The fiber blend used for fabric sample 1 makes it possible to make a light weight cotton/nylon/ oxidized bioregional polyacrylonitrile blend fabric treated by flame retardant chemicals that meet the performance requirements on the electric arc rating for HRC level II in NFPA standard 70 E (2012).

Claims

1. Fabric comprising:

- a) 3 to 45 percent by weight of polyamide fiber;
- b) 5 to 35 percent by weight of an oxidized polymeric biregional fiber comprising an oxidized polymer selected from the group consisting of acrylonitrile-based homopolymers, acrylonitrile-based copolymers, acrylonitrile-based terpolymers, and combinations thereof;
- c) 1 to 20 percent by weight of FR rayon fiber; and

characterized in that the fabric comprises 20 to 90 percent by weight of natural cellulose fiber.

2. The fabric of claim 1 wherein the polyamide fiber comprises nylon 6,6.

3. The fabric of claim 1 wherein the oxidized polymeric biregional fiber comprises oxidized polyacrylonitrile fiber.

4. The fabric of claim 1 wherein the fabric has a basis weight of from 101.7 g/m² to 508.6 g/m².

5. The fabric of claim 1 wherein the fabric has a basis weight of 101.7 g/m² to 220.4 g/m².
6. The fabric of claim 1 wherein the fabric is treated with flame retardant chemistry.
7. The fabric of claim 1, wherein the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise the biregional fibers.
8. The fabric of claim 1, wherein the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise 50 to 100 percent by weight of the biregional fibers in the fabric.
9. The fabric of claim 1, wherein the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise at least 75 percent by weight of the biregional fibers in the fabric.
10. The fabric of claim 1, wherein the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise 100 percent by weight of the biregional fibers in the fabric.
11. The fabric of claim 1 further comprising from 1 to 9 percent by weight of *para*-aramid fiber.
12. The fabric according to claim 1 comprising:
 - a) 20 to 90 percent by weight of natural cellulose fiber;
 - b) 3 to 45 percent by weight of polyamide fiber;
 - c) 1 to 9 percent by weight of *para*-aramid fiber;
 - d) 1 to 20 percent by weight of FR rayon fiber; and
 - e) 5 to 35 percent by weight of biregional fiber comprising an oxidized polymer selected from the group consisting of acrylonitrile-based homopolymers, acrylonitrile-based copolymers, acrylonitrile-based terpolymers, and combinations thereof,wherein the fabric has a basis weight of from 101.7 g/m² to 508.6 g/m², and wherein the fabric is woven and comprises warp yarns and filling yarns, wherein the filling yarns comprise the majority of the FR rayon, *para*-aramid and the biregional fibers.
13. The fabric of claim 12 wherein the filling yarns comprise 100 percent by weight of the FR rayon fibers, the *para*-aramid fibers and the biregional fibers.

Patentansprüche

1. Stoff, umfassend:
 - a) zu 3 bis 45 Gewichtsprozent Polyamidfaser;
 - b) zu 5 bis 35 Gewichtsprozent eine oxidierte polymere biregionale Faser, umfassend ein oxidiertes Polymer, ausgewählt aus der Gruppe bestehend aus Homopolymeren auf Acrylnitrilbasis, Copolymeren auf Acrylnitrilbasis, Terpolymeren auf Acrylnitrilbasis und Kombinationen davon;
 - c) zu 1 bis 20 Gewichtsprozent FR-Rayon-Faser; und**dadurch gekennzeichnet, dass** der Stoff zu 20 bis 90 Gewichtsprozent natürliche Cellulosefasern umfasst.
2. Stoff nach Anspruch 1, wobei die Polyamidfaser Nylon 6,6 umfasst.
3. Stoff nach Anspruch 1, wobei die oxidierte polymere biregionale Faser oxidierte Polyacrylnitrilfaser umfasst.
4. Stoff nach Anspruch 1, wobei der Stoff ein Flächengewicht von 101,7 g/m² bis 508,6 g/m² aufweist.
5. Stoff nach Anspruch 1, wobei der Stoff ein Flächengewicht von 101,7 g/m² bis 220,4 g/m² aufweist.
6. Stoff nach Anspruch 1, wobei der Stoff mit flammhemmender Chemie behandelt ist.
7. Stoff nach Anspruch 1, wobei der Stoff gewebt ist und Kettgarne und Schussgarne umfasst, wobei die Schussgarne die biregionalen Fasern umfassen.

EP 3 245 320 B1

8. Stoff nach Anspruch 1, wobei der Stoff gewebt ist und Kettgarne und Schussgarne umfasst, wobei die Schussgarne 50 bis 100 Gewichtsprozent der biregionalen Fasern im Stoff umfassen.
- 5 9. Stoff nach Anspruch 1, wobei der Stoff gewebt ist und Kettgarne und Schussgarne umfasst, wobei die Schussgarne mindestens 75 Gewichtsprozent der biregionalen Fasern im Stoff umfassen.
10. Stoff nach Anspruch 1, wobei der Stoff gewebt ist und Kettgarne und Schussgarne umfasst, wobei die Schussgarne 100 Gewichtsprozent der biregionalen Fasern im Stoff umfassen.
- 10 11. Stoff nach Anspruch 1, ferner umfassend zu 1 bis 9 Gewichtsprozent para-Aramidfaser.
12. Stoff nach Anspruch 1, umfassend:
- 15 a) zu 20 bis 90 Gewichtsprozent natürliche Cellulosefaser;
b) zu 3 bis 45 Gewichtsprozent Polyamidfaser;
c) zu 1 bis 9 Gewichtsprozent para-Aramidfaser;
d) zu 1 bis 20 Gewichtsprozent FR-Rayon-Faser; und
e) zu 5 bis 35 Gewichtsprozent biregionale Faser, umfassend ein oxidiertes Polymer, ausgewählt aus der Gruppe bestehend aus Homopolymeren auf Acrylnitrilbasis, Copolymeren auf Acrylnitrilbasis, Terpolymeren auf Acrylnitrilbasis und Kombinationen davon,
20 wobei der Stoff ein Flächengewicht von 101,7 g/m² bis 508,6 g/m² aufweist, und wobei der Stoff gewebt ist und Kettgarne und Schussgarne umfasst, wobei die Schussgarne die Mehrheit der FR-Rayon-, para-Aramid- und der biregionalen Fasern umfassen.
- 25 13. Stoff nach Anspruch 12, wobei die Schussgarne 100 Gewichtsprozent der FR-Rayon-Fasern, der para-Aramid-Fasern und der biregionalen Fasern umfassen.

Revendications

- 30 1. Tissu comprenant :
- a) 3 à 45 pour cent en poids de fibre de polyamide ;
b) 5 à 35 pour cent en poids d'une fibre birégionale polymère oxydée comprenant un polymère oxydé choisi dans le groupe constitué par les homopolymères à base d'acrylonitrile, les copolymères à base d'acrylonitrile, les terpolymères à base d'acrylonitrile et leurs combinaisons ;
c) 1 à 20 pour cent en poids de fibre de rayonne FR ; et
35 **caractérisé en ce que** le tissu comprend 20 à 90 pour cent en poids de fibre de cellulose naturelle.
- 40 2. Tissu selon la revendication 1, dans lequel la fibre de polyamide comprend du nylon 6,6.
3. Tissu selon la revendication 1, dans lequel la fibre birégionale polymère oxydée comprend une fibre de polyacrylonitrile oxydée.
- 45 4. Tissu selon la revendication 1, dans lequel le tissu a un grammage de 101,7 g/m² à 508,6 g/m².
5. Tissu selon la revendication 1, dans lequel le tissu a un grammage de 101,7 g/m² à 220,4 g/m².
6. Tissu selon la revendication 1, dans lequel le tissu est traité avec un agent chimique retardateur de flammes.
- 50 7. Tissu selon la revendication 1, dans lequel le tissu est tissé et comprend des fils de chaîne et des fils de trame, dans lequel les fils de trame comprennent les fibres birégionales.
8. Tissu selon la revendication 1, dans lequel le tissu est tissé et comprend des fils de chaîne et des fils de trame, dans lequel les fils de trame comprennent 50 à 100 pour cent en poids des fibres birégionales dans le tissu.
- 55 9. Tissu selon la revendication 1, dans lequel le tissu est tissé et comprend des fils de chaîne et des fils de trame, dans lequel les fils de trame comprennent au moins 75 pour cent en poids des fibres birégionales dans le tissu.

EP 3 245 320 B1

10. Tissu selon la revendication 1, dans lequel le tissu est tissé et comprend des fils de chaîne et des fils de trame, dans lequel les fils de trame comprennent 100 pour cent en poids des fibres birégionales dans le tissu.

11. Tissu selon la revendication 1, comprenant en outre de 1 à 9 pour cent en poids de fibre de para-aramide.

12. Tissu selon la revendication 1, comprenant :

a) 20 à 90 pour cent en poids de fibre de cellulose naturelle ;

b) 3 à 45 pour cent en poids de fibre de polyamide ;

c) 1 à 9 pour cent en poids de fibre de *para*-aramide ;

d) 1 à 20 pour cent en poids de fibre de rayonne FR ; et

e) 5 à 35 pour cent en poids de fibre birégionale comprenant un polymère oxydé choisi dans le groupe constitué par les homopolymères à base d'acrylonitrile, les copolymères à base d'acrylonitrile, les terpolymères à base d'acrylonitrile et leurs combinaisons,

dans lequel le tissu a un grammage de 101,7 g/m² à 508,6 g/m², et dans lequel le tissu est tissé et comprend des fils de chaîne et des fils de trame, dans lequel les fils de trame comprennent la majorité des fibres de rayonne FR, de para-aramide et des fibres birégionales.

13. Tissu selon la revendication 12, dans lequel les fils de trame comprennent 100 pour cent en poids des fibres de rayonne FR, des fibres de para-aramide et des fibres birégionales.

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

- US 6358608 B [0006]
- US 20110165397 A [0007]
- US 20110239618 A [0008]
- US 20140047625 A [0009]
- WO 2010135214 A [0011]
- WO 2011050257 A [0012]
- WO 2011050257 A2 [0024]