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(54) **FABRIC AND YARN FOR PROTECTIVE GARMENTS**

GEWEBE UND GARN FÜR SCHUTZKLEIDUNG

TISSU ET FIL POUR VETEMENTS DE PROTECTION

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Description

Field of the Invention

[0001] The invention is directed to a fabric and a yarn used to make protective garments.

Background of the Invention

[0002] Protective clothing refers to primary and secondary protective clothing (per ASTM Standard F1002-86). Primary protective clothing is designed for activities where significant exposure to molten substance splash, radiant heat, or flame is likely to occur. Secondary protective clothing, on the other hand, is designed for continuous wear in areas where intermittent exposure to molten substance splash, radiant heat, and/or flame is possible.

[0003] Protective clothing in the work place is important because it is the employer's responsibility to identify risks and hazards in the workplace and seek out appropriate protective garments and equipment for the protection of workers. Common workplace hazards include, for example: flammable liquids, flammable soils, molten metals, sparks, slag from flame cutting, welding, open flames, high voltage electrical discharges, electric arc events, vapors from volatile liquids, and combustible dusts. These hazards may be encountered in foundries, at electrical utilities, in the chemical, oil, gas and petrochemical industries, in auto racing, to mention a few.

[0004] Fabrics have been developed for use in protective clothing. Those fabrics may be made with treated fibers, inherently flame resistant fibers, or combinations thereof. A treated fiber is, typically, a conventional textile fiber that has been treated with a flame retardant, a chemical substance used to impart flame resistance. For example, two treated fibers are FR cotton or FR rayon, both FR cellulosics. Inherently flame resistant fibers are those fibers that have flame resistance as an essential characteristic of the fiber. For example, inherently flame resistant fibers include: aramids, polyamide imides, melamines, polybenzimidazole (PBI), polyimides, polyphenylene benzodisoxazole (PBO), polyphenylene sulfide (PPS), polyetherether ketone (PEEK), and the like. Most often, these fibers are blended together to obtain a yarn for a fabric with a particular blend of properties. Those properties include thermal protection, static resistance, comfort, durability, stability, appearance, ease of laundry maintenance, color, and relative cost.

[0005] Popular fabrics include: PBI GOLD®, NOMEX®, NOMEX® IIIA, COMFORT BLEND®, NOMEX Freestyle, and INDURA® ULTRASOFT. PBI GOLD® is a 40% PBI/60% aramid blend (all % are by weight of the fabric). NOMEX® is a blend of 95% meta-aramid (NOMEX) fiber/5% para-aramid (KEVLAR) fiber. NOMEX IIIA is a blend of 93% meta-aramid (NOMEX) fiber/5% para-aramid (KEVLAR) fiber/2% static dissipative fiber. COMFORT BLEND® is 65% NOMEX IIIA/35% FR rayon blend. NOMEX Freestyle is 93% NOMEX IIIA/5% para-aramid (KEVLAR) fiber/2% antistatic fiber. INDURA ULTRASOFT is 88% FR cotton/12% nylon blend. Each of these fabrics has its own unique blend of properties. *Flame Resistant Protective Apparel, An Industry Update 2001/2002,* Bulwark Protective Apparel, a Division of VF Workwear, Inc., Nashville, TN, incorporated herein by reference.

[0006] As an example US-B-6 489 256 discloses a fire escape blanket and other melamine resin containing compositions and products with fire blocking properties. The product has, at its broadest range, about 15-80 parts by weight a melamine resin, up to about 80 parts by weight an aramid fiber, and up to about 80 parts by weight a modacrylic fiber.

[0007] In US-A-5 356 700 a fiber fabric useful for flame-resistant garment is shown, which is composed of yarns comprising a blend of 65 to 95% by weight of an aromatic polyamide fiber-containing fiber component with 5 to 40% by weight of a polyester fiber component. The aromatic polyamide fiber= containing fiber component comprising 50 to 100% by weigth of aromatic polyamide fibers and 0 to 50% by weight of cellulose fibers and the fiber fabric having a limiting oxygen index of 26 or more. In one example the yarn may comprise an aramid fiber (denier 0.4-3), FR cellulosic fiber, and a polyester fiber.

[0008] There exists, however, a need for new fabrics that will meet new and emerging needs of the industry.

Summary of the Invention

[0009] The present invention is a yarn or fabric useful in protective garments. The yarn or fabric is made of flame resistant fibers and microdenier flame resistant fibers. The flame resistant fibers are selected from the group consisting of inherently flame resistant fibers, treated fibers, and combinations thereof. The microdenier flame resistant fibers are selected from the group consisting of microdenier inherently flame resistant fibers, microdenier treated fibers, and combinations thereof. The weight ratio of said flame resistant fibers to said microdenier flame resistant fibers is in the range of 4-9:2-6.

Description of the Invention

[0010] Fabrics are planar structures made of fibers and/or yarns assembled by various means such as weaving,

knitting, tufting, felting, braiding, or bonding of webs to give the structure sufficient strength and other properties required for its intended use. A yarn is a generic term for a continuous strand of textile fibers, filaments, or materials in a form suitable for knitting, weaving, or otherwise intertwining to form a fabric. Yarn occurs, for example, in the following forms: (1) a number of fibers (e.g., staple) twisted together (spun yarn); (2) a number of filaments laid together without twist (a zero-twist yarn); (3) a number of filaments laid together with a degree of twist; (4) a single filament with or without twist (a monofilament); or (5) a narrow strip of materials, such as paper, plastic film, or metal foil, with or without twist, intended for use in a textile construction.

[0011] The yarns and fabrics discussed hereinafter are preferably used as secondary protective clothing, but may be used otherwise, for example, as primary protective clothing. The garments formed from these yarns and fabrics include, but are not limited to, shirts, pants, coveralls, overalls, jackets, liners, coats, parkas, headwear, and footwear. The fabrics may be laminated or combined with other fabrics or materials to enhance functionality.

[0012] The fabrics are preferably woven or knitted. Woven fabrics include plain, twill, and satin weaves. Knitted fabrics include warp and weft knitted fabrics. The fabrics are preferably made of the yarn hereinafter described, but are not so limited. Instead, fabrics within the scope of present invention have a weight ratio of flame resistant fibers (i.e., inherently flame resistant fibers and treated fibers) to microdenier flame resistant fibers (i.e., inherently flame resistant fibers and treated fibers having microdeniers) is in the range of 4-9:2-6. Preferably, the ratio is 1:1. Alternatively, the ratio of inherently flame resistant fibers:microdenier flame resistant fibers:treated fibers is in the range of 1-3:2-6:3-6. Preferably, the ratio is 2:5:3. Other fibers may be added so long as the foregoing ratios are maintained. For example, a conventional textile fiber could be added to a blend having the foregoing ratio.

[0013] The invention will be further described with reference to a yarn, it being understood that the foregoing fabric discussion is applicable to the following yarn as well as the following is applicable to foregoing fabric discussion.

[0014] The yarn comprises: 10-30% by weight of the yarn of an inherently flame resistant fiber (filament or staple); 20-60% by weight of a microdenier flame resistant fiber (filament or staple); and 20-60% by weight of a treated fiber (filament or staple). Preferably, the yarn comprises 20% of the inherently flame resistant fiber; 50% of the microdenier flame resistant fiber; and 30% of the treated fiber.

[0015] The inherently flame resistant fibers may be selected from the group consisting of: aramids, polyamide imides; melamines, polybenzimidazoles (PBI), polyimides, polyphenylene benzodisoxazoles (PBO), polyphenylene sulfides (PPS), polyether ketones (PEK), and polyetherether ketones (PEEK), and the like. These fibers are known and commercially available. For example, aramids (meta-aramids and para-aramids) are available as TWARON®, CONEX®, and TECHNORA® from Teijin Co. of Osaka, Japan; NOMEX® and KEVLAR® from DuPont of Wilmington, Delaware; P84 from Imitech of Austria; and KERMEL® from Kermel Company of Colmar, France. Melamines (melamine formaldehydes) are available as BASOFIL® from Basofil Fibers LLC of Charlotte, North Carolina. PBI is available from Celanese Advanced Mateirals, Inc, of Charlotte, North Carolina. PBO is available as ZYLON® from Toyobo Co. Ltd. of Osaka, Japan. The preferred inherently flame resistant fibers include aramids, melamines, PBI, and PBO. Most preferred is PBI.

[0016] The treated fiber may be any conventional fiber that has been treated with a conventional flame retardant. For example, treated fibers may include FR cellulosics. Cellulosics include cotton, rayon, acetate, and triacetate. Preferred treated fibers FR cotton and FR rayon. Most preferred is FR rayon.

[0017] The microdenier flame resistant fiber may be any inherently flame resistant fiber or treated fiber having a denier less than 1 (or 0.1 tex per filament, or a diameter less than 10 micrometers). Preferably, this fiber is a microdenier inherently flame resistant fiber. Most preferably, this fiber is a microdenier aramid, for example, microdenier TWARON® from Teijin Co. of Osaka, Japan.

[0018] The yarns are made in a conventional fashion. Moreover, the yarns may include-other conventional textile fibers (natural or man-made) provided that the addition of such fibers does not have a detrimental impact on the overall performance of the yarns, fabric, or garment.

[0019] The foregoing invention may be-better understood with reference to the following non-limiting examples.

[0020] In the Table, the invention is compared to other fabrics used in protective garments. The test methods are set forth in the Table. INV refers to the inventive fabric which was made from yarns consisting of 20% PBI staple, 50% microdenier aramid (0.8 denier per filament, 2 inch (5cm) staple), and 30% FR rayon. The comparative materials were conventional fabrics as noted above.

Table

Properties	Test Method	INV	Indura Ultrasoft	Indura Ultrasoft	Nomex Freestyle	Nomex Freestyle	Comfort Blend-Blue	Comfort Blend-Blue	Comfort Blend-Denim	PBI Gold	PBI Gold
Weight, gsm (oz/yd^2) Nominal		152.58 (4.5)	186.48 (5.5)	237.34 (7.0)	152.58 (4.5)	203.43 (6.0)	186.48 (5.5)	220.39 (6.5)	152.58 (4.5)	152.58 (4.5)	203.43 (6.0)
Weight, gsm (oz/yd^2) Actual		158.00 (4.66)	200.38 (5.91)	255.65 (7.54)	147.83 (4.36)	208.18 (6.14)	189.53 (5.59)	213.61 (6.30)	150.20 (4.43)	154.61 (4.56)	
Weave		Twill	Twill	Twill	Plain	Plain	Plain	Twill	Plain	Twill	
Moisture Regain	D2654	6.66	7.56	7.66	5.45	5.51	5.84	5.49	6.53	6.84	
Air Permeability $cm^3/cm^2/s$ ($ft^3/ft^2/min$)	D737	51.1 (100.6)	32.8 (64.6)	16.9 (33.2)	111.5 (219.5)	36.2 (71.2)	45.8 (90.1)	37.8 (74.4)	83.8 (164.9)	41.0 (80.8)	
Elmendorf Tear Resistance N (W x F) (lbf(W x F))	F1506/ D1424	86.3 x 92.1 (19.4 x 20.7)	22.7 x 14.7 (5.1 x 3.3)	37.4 x 31.1 (8.4 x 7.0)	36.5 x 57.4 (8.2 x 12.9)	32.0 x 55.2 (7.2 x 12.4)	6.4 x 8.6 (2.5 x 3.4)	13.8 x 19.1 (3.1 x 4.3)	31.6 x 32.9 (7.1 x 7.4)	139.2 x 145.0 (31.3 x 32.6)	
Tear Strength (Tongue) (Single Rip)	F1506 D2261	13.1 x 10.0	2.1 x 2.2	5.0 x 4.0	11.3 x 8.1	7.5 x 4.5	1.9 x 1.3	2.5 x 1.7	5.6 x 4.3	19.2 x 16.6	
Grab Strength (GS) N(W x F) (1bf(WxF))	F1506/ D5034	732.0x546. 2 (164.6 x 122.8)	322.5 x 306.9 (72.5 x 69.6)	338.0 x 308.2 (76.0 x 69.3)	893.6x480.4 (200.9 x 108.3)	1338.4x788.2 (300.9 x 177.2)	560.0 x 357.6 (125.9 x 80.4)	699.2x485.3 (157.2 x 109.1)	487.9x267.3 (109.7 x 60.1)	693.0x521.3 (155.8 x 117.2)	

(continued)

Properties	Test Method	INV	Indura Ultrasoft	Indura Ultrasoft	Nomex Freestyle	Nomex Freestyle	Comfort Blend-Blue	Comfort Blend-Blue	Comfort Blend-Denim	PBI Gold	PBI Gold
GS After Thermal Exposure (8 sec) N(W x F) (Ibf(W x F))		59.2 x 52.9 (13.3 x 11.9)	1.8 x 3.1 (0.4 x 0.7)	2.2 x 3.1 (0.5 x 0.7)	64.9 x 29.8 (14.6 x 6.7)	88.1 x 80.9 (19.8 x 18.2)	21.3 x 16.5 (4.8 x 3.7)	38.2 x 42.7 (8.6 x 9.6)	15.6 x 8.0 (3.5 x 1.8)	92.5 x 72.5 (20.8 x 16.3)	
Tensile, 1-Inch Strip N(W x F) (Ibf(W x F))	D5035	525.3x534.7 (118.1 x 120.2)	276.7x226.8 (62.2 x 51.0)	431.5 x 232.6 (97.0x52.3)	367.4x242.4 (82.6 x 54.5)	509.7x373.6 (114.6 x 84.0)	334.9x246.0 (75.3 x 55.3)	397.2x254.0 (89.3 x 57.1)	303.4 x 176.1 (68.2 x 39.6)	111.2 x 477.3 (125.0 x 107.3)	
Taber Abrasion H18 500gm (cycles to failure)	D5035	231	137	108	86	169	99	179	69	138	
Laundry Shdnkage(%) 5X Wash	AATCC 135	1.2 x 2.5	0.8 x 2.6	1.4 x 1.1	2.6 x 2.6	2.2 x 3.4	1.7 x 0.8	1.1 x 1.3	0.5x2.0	2.0 x 1.4	
25X Wash		2.8 x 4.1	0.7 x 2.9	3.6 x 1.3	4.3 x 4.2	3.2 x 4.7	3.3 x 2.7	2.1 x 2.8	5.5 x 2.0	2.9 x 2.9	
Heat and Thermal Shrinkage(%) 10.0 max	NFPA 2112	1.3 x 1.0	2.4 x 0.6	2.7 x 0.0	2.2 x 1.3	1.3 x 1.3	3.3 x 3.0	3.0 x 2.6	8.6 x 4.6	1.3 x 1.0	
Flammability	D6413										
Original											

(continued)

Properties	Test Method	INV	Indura Ultrasoft	Indura Ultrasoft	Nomex Freestyle	Nomex Freestyle	Comfort Blend-Blue	Comfort Blend-Blue	Comfort Blend-Denim	PBI Gold	PBI Gold
Char Length cm(in) 6.0 max		1.02 x 1.24 (0.40 x 0.49)	7.29 x 8.15 (2.87 x 3.21)	7.19 x 6.43 (2.83x2.53)	4.29 x 5.41 (1.69 x 2.13)	4.80 x 4.98 (1.89 x 1.96)	3.23 x 2.82 (1.27 x 1.11)	2.95 x 2.74 (1.16 x 1.08)	3.76 x 3.56 (1.48 x 1.40)	1.09 x 1.45 (0.43x0.57)	
Afterflame (sec) 2.0 max		0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	
Afterglow (sec)		1.02 x 1.07	1.19 x 0.90	1.08 x 1.19	0.86 x 0.83	1.04 x 1.15	0.92 x 0.72	0.88 x 1.16	1.02 x 1.07	20.49 x 16.51	
25X Wash/Dry											
Char Length cm(in) 6.0 max		1.02 x 0.69 (0.41 x 0.27)	6.35 x 6.73 (2.50x2.65)	6.91 x 6.32 (2.72 x 2.49)	5.28 x 3.86 (2.08 x 1.52)	4.78 x 6.10 (1.88 x 2.40)	2.77 x 1.70 (1.09 x 0.67)	2.13 x 2.29 (0.84 x 0.90)	3.71 x 3.18 (1.46 x 1.25)	1.12 x 0.96 (0.44 x 0.38)	
Afterflame (sec) 2.0 max		0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	0.0 x 0.0	
Afterglow (sec)		1.48 x 1.28	0.91 x 0.66	1.05 x 1.36	3.41 x 3.10	6.60 x 2.39	0.93 x 0.89	1.07 x 0.80	1.41 x 1.39	29.50 x 26.33	
Thermal Protective Performance (TPP)	NFPA 2112	11.3	7.4	9.6	11.6	13.1	11.9	12.5	10.7	11.7	12.9
TPP/gsm (TPP/osy)		0.074 (2.5)	0.038 (1.3)	0.038 (1.3)	0.080 (2.7)	0.065 (2.2)	0.062 (2.1)	0.059 (2.0)	0.071 (2.4)	0.077 (2.6)	0.065 (2.2)
Preformance (RPP)		8.4	7.6	9.0	5.6	7.6	7.5	7.9	6.3	7.4	8.1
ARC FLASH TESTING											

(continued)

Properties	Test Method	INV	Indura Ultrasoft	Indura Ultrasoft	Nomex Freestyle	Nomex Freestyle	Comfort Blend-Blue	Comfort Blend-Blue	Comfort Blend-Denim	PBI Gold	PBI Gold
Single Layer wt gsm (osv) n=3 laundering		159.4 (4.7)	189.9 (5.6)	254.3 (7.5)	152.6 (4.5)	217.0 (6.4)	189.9 (5.6)	217.0 (6.4)	152.6 (4.5)	156.0 (4.6)	203.4 (6.0)
Arc Thermal Performance Linear (ATPV)	F1959/ F1959M	5.9	5.5	8.1	4.8	5.7	5.3	6.0	4.8	6.6	7.5
ATPV/GSM (ATPV/OSY)		0.037 (1.26)	0.027 (0.98)	0.032 (1.80)	0.032 (1.10)	0.027 (0.89)	0.028 (0.95)	0.028 (0.94)	0.032 (1.07)	0.043 (1.43)	0.037 (1.25)
Linear HAF		67.4	64.1	73.4	54.4	62.1	63.3	65.3	60.0	68.3	70.6
Arc Thermal Performance Logistical (ATPV)	F1959/ F1959M	6.0	5.6	7.9	4.8	5.9	5.5	6.2	4.8	6.5	7.9
ATPV/GSM (ATPV/OSY)		0.038 (1.28)	0.028 (1.00)	0.031 (1.05)	0.032 (1.07)	0.028 (0.92)	0.029 (0.98)	0.029 (0.97)	0.032 (1.07)	0.042 (1.41)	0.039 (1.32)

(continued)

Properties	Test Method	INV	Indura Ultrasoft	Indura Ultrasoft	Nomex Freestyle	Nomex Freestyle	Comfort Blend-Blue	Comfort Blend-Blue	Comfort Blend-Denim	PBI Gold	PBI Gold
Single Layer with nominal 152.6 gsm (4.5 osy) Cotton Tshirt wt gsm (osy) n=3 laundering		311.93 (9.2)	342.45 (10.1)	406.87 (12.0)	301.76 (8.9)	369.57 (10.9)	342.45 (10.1)	369.57 (10.9)	305.15 (9.0)	308.54 (9.1)	356.01 (10.5)
Linear (E_{bt})	F1959/ F1959M	16.0	10.3	14.7	9.2	13.4	11.2	13.1	9.0	14.7ATPV 15.8	17.9ATPV 18.8
E_{bt}/GSM (E_{bt}/OSY)		0.051 (1.74)	0.030 (1.02)	0.036 (1.23)	0.030 (1.00)	0.036 (1.23)	0.033 (1.11)	0.035 (1.20)	0.029 (1.00)	0.048ATPV (1.62ATPV) 0.051 (1.74)	0.050ATPV (1.70ATPV) 0.053 (1.79)
Linear HAF		85.4	80.9	84.8	77.5	78.2	82.1	82.6	78.3	83.1	84.9
Logistical (E_{bt})	F1959/ F1959M	16.8	10.6	15.6	9.3	14.4	11.4	13.3	8.9	17.1	19.2ATPV 21.6
E_{bt}/GSM (E_{bt}/OSY)		0.054 (1.83)	0.030 (1.05)	0.038 (1.30)	0.031 (1.04)	0.039 (1.32)	0.033 (1.13)	0.036 (1.22)	0.029 (0.99)	0.055 (1.88)	0.054ATPV (1.83ATPV) 0.061 (2.06)
Dynamic Flame (sec)		30.0	1.1	1.6	1.1	1.6	1.3		1.0	18.7	

(continued)

Properties	Test Method	INV	Indura Ultrasoft	Indura Ultrasoft	Nomex Freestyle	Nomex Freestyle	Comfort Blend-Blue	Comfort Blend-Blue	Comfort Blend-Denim	PBI Gold	PBI Gold
Manikin Flame Resistance (body burn rating) (3 sec) Tshirt/brief (50.0 max)	NFPA 2112 F1930										
3 Second Exposure											
% Total Burn		21.1		55.2	24.9			20.2	33.9	9.6	
% 2nd Degree Burn		20.6		35.3	24.6			20.2	33.6	9.6	
% 3rd Degree Burn		0.3		19.6	0.3			0.0	0.3	0.0	
4 Second Burn											
% Total Burn		41.8		69.4	47.8			38.3	42.6	37.7	
% 2nd Degree Burn		41.5		25.4	38.5			37.7	38.5	37.7	

(continued)

Properties	Test Method	INV	Indura Ultrasoft	Indura Ultrasoft	Nomex Freestyle	Nomex Freestyle	Comfort Blend-Blue	Comfort Blend-Blue	Comfort Blend-Denim	PBI Gold	PBI Gold
% 3rd Degree Burn		0.3		44.0	9.3			0.6	4.1	0.0	

ATPV = arch thermal performance value E_{bt} = energy of break open threshold
GSM = grams per square meter HAF = heat attenuation factor
OSY = ounces per square yard W x F = warp x fill

Claims

1. A yarn for use in industrial protective garments and having good thermal barrier properties, durability and comfort ratings, **characterized in that** it comprises:

   10 to 30% by weight of an inherently flame resistant fiber;
   20 to 60% by weight of a microdenier (having a denier less than 1 or 0.1 tex per filament or a diameter less than 10 micrometers) aramid fiber; and
   20 to 60% by weight of a treated fiber.

2. A yarn according to claim 1, **characterized in that** it comprises 15 to 25% by weight of said inherently flame resistant fiber.

3. A yarn according to claim 1 or claim 2, **characterized in that** said inherently flame resistant fiber is selected from the group consisting of an aramid, a polyamide imide, a melamine, a polybenzimidazole, a polyimide, a polyphenylene benzobisoxazole, a polyphenylene sulfide, a polyether ketone, a polyetherether ketone and a combination thereof.

4. A yarn according to any one of claims 1 to 3, **characterized in that** said inherently flame resistant fiber is a polybenzimidazole.

5. A yarn according to any one of claims 1 to 4, **characterized in that** it comprises 45 to 55% by weight of said microdenier aramid fiber.

6. A yarn according to any one of claims 1 to 5, **characterized in that** it comprises 25 to 35% by weight of said treated fiber.

7. A yarn according to any one of claims 1 to 6, **characterized in that** said treated fiber is an FR cellulosic.

8. A yarn according to any one of claims 1 to 7, **characterized in that** said treated fiber is an FR rayon.

9. A yarn according to any one of claims 1 to 8, **characterized in that** said inherently flame resistant fiber is a PBI staple, said microdenier aramid fiber is a microdenier aramid staple and said treated fiber is an FR rayon.

10. A fabric for use in industrial protective garments and having good thermal barrier properties, durability and comfort ratings, **characterized in that** it comprises:

    10 to 30% by weight of an inherently flame resistant fiber;
    20 to 60% by weight of a microdenier (having a denier less than 1 or 0.1 tex per filament or a diameter less than 10 micrometers) aramid fiber; and
    20 to 60% by weight of a treated fiber.

11. A fabric according to claim 10, **characterized in that** it comprises 15 to 25% by weight of said inherently flame resistant fiber.

12. A fabric according to claim 10 or claim 11, **characterized in that** said inherently flame resistant fiber is selected from the group consisting of an aramid, a polyamide imide, a melamine, a polybenzimidazole, a polyimide, a polyphenylene benzobisoxazole, a polyphenylene sulfide, a polyether ketone, a polyetherether ketone and a combination thereof.

13. A fabric according to any one of claims 10 to 12, **characterized in that** said inherently flame resistant fiber is a polybenzimidazole.

14. A fabric according to any one of claims 10 to 13, **characterized in that** it comprises 45 to 55% by weight of said microdenier aramid fiber.

15. A fabric according to any one of claims 10 to 14, **characterized in that** it comprises 25 to 35% by weight of said treated fiber.

16. A fabric according to any one of claims 10 to 15, **characterized in that** said treated fiber is an FR cellulosic.

17. A fabric according to any one of claims 10 to 16, **characterized in that** said treated fiber is an FR rayon.

18. A fabric according to any one of claims 10 to 17, **characterized in that** said inherently flame resistant fiber is a PBI staple, said microdenier aramid fiber is a microdenier aramid staple and said treated fiber is an FR rayon.

19. A fabric according to any one of claims 10 to 18, **characterized in that** it has a Taber abrasion resistance of at least 180 cycles to failure.

20. A fabric according to any one of claims 10 to 19, **characterized in that** it has a Taber abrasion resistance of approximately 230 cycles to failure.

21. A fabric according to any one of claims 10 to 20, **characterized in that** it has a thermal protective performance per weight of at least 0.059 TPP/GSM (2.0 TPP/OSY).

22. A fabric according to any one of claims 10 to 21, **characterized in that** it has a thermal protective performance per weight of approximately 0.074 TPP/GSM (2.5 TPP/OSY).

23. A fabric according to any one of claims 10 to 22, **characterized in that** it has an arc thermal performance logistical value per weight of at least 0.028 ATPV/GSM (1.00 ATPV/OSY).

24. A fabric according to any one of claims 10 to 23, **characterized in that** it has an arc thermal performance logistical value per weight of approximately 0.038 ATPV/GSM (1.28 ATPV/OSY).

25. A fabric according to any one of claims 10 to 24, **characterized in that** it has a tear resistance of at least 66.72 x 66.72 N(W x F) [15 x 15 lbf(W x F)].

26. A fabric according to any one of claims 10 to 25, **characterized in that** it has a tear resistance of approximately 86.3 x 92.1 N(W x F) [19.4 x 20.7 lbf(W x F)].

27. A fabric according to any one of claims 10 to 26, **characterized in that** it has a tear strength of at least 10 x 5 (tongue)(single rip).

28. A fabric according to any one of claims 10 to 27, **characterized in that** it has a tear strength of approximately 13.1 x 10.0 (tongue)(single rip).

29. A fabric according to any one of claims 10 to 28, **characterized in that** it has a tensile strength of at least 444.8 x 444.8 N(W x F) [100 x 100 lbf(W x F)] for a 1 inch strip.

30. A fabric according to any one of claims 10 to 29, **characterized in that** it has a tensile strength of approximately 525.3 x 534.7 N(W x F) [118.1 x 120.2 lbf(W x F)] for a 1 inch strip.

Patentansprüche

1. Garn zur Verwendung bei industriellen Schutzbekleidungen und mit guten Wärmebarriereeigenschaften, guter Beständigkeit und guten Komfortbewertungen, **dadurch gekennzeichnet, dass** es umfasst:

    10 bis 30 Gew.-% einer inhärent flammfesten Faser;
    20 bis 60 Gew.-% einer Micro-Denier-Aramidfaser (mit einem Denier von weniger als 1 oder 0,1 tex pro Filament oder einem Durchmesser von weniger als 10 Mikrometern); und
    20 bis 60 Gew.-% einer behandelten Faser.

2. Garn nach Anspruch 1, **dadurch gekennzeichnet, dass** es 15 bis 25 Gew.-% der inhärent flammfesten Faser umfasst.

3. Garn nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die inhärent flammfeste Faser aus der Gruppe,

bestehend aus einem Aramid, einem Polyamidimid, einem Melamin, einem Polybenzimidazol, einem Polyimid, einem Polyphenylenbenzobisoxazol, einem Polyphenylensulfid, einem Polyetherketon, einem Polyetheretherketon und einer Kombination davon, ausgewählt ist.

4. Garn nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** die inhärent flammfeste Faser ein Polybenzimidazol ist.

5. Garn nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** es 45 bis 55 Gew.-% der Micro-Denier-Aramidfaser umfasst.

6. Garn nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** es 25 bis 35 Gew.-% der behandelten Faser umfasst.

7. Garn nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** die behandelte Faser flammfeste Cellulose ist.

8. Garn nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** die behandelte Faser flammfeste Kunstseide ist.

9. Garn nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** die inhärent flammfeste Faser eine PBI-Stapelfaser ist, die Micro-Denier-Aramidfaser eine Micro-Denier-Aramidstapelfaser ist und die behandelte Faser flammfeste Kunstseide ist.

10. Gewebe zur Verwendung bei industrieller Schutzbekleidungen und mit guten Wärmebarriereeigenschaften, guter Beständigkeit und guten Komfortbewertungen, **dadurch gekennzeichnet, dass** es umfasst:

10 bis 30 Gew.-% einer inhärent flammfesten Faser;
20 bis 60 Gew.-% einer Micro-Denier-Aramidfaser (mit einem Denier von weniger als 1 oder 0,1 tex pro Filament oder einem Durchmesser von weniger als 10 Mikrometern); und
20 bis 60 Gew.-% einer behandelten Faser.

11. Gewebe nach Anspruch 10, **dadurch gekennzeichnet, dass** es 15 bis 25 Gew.-% der inhärent flammfesten Faser umfasst.

12. Gewebe nach Anspruch 10 oder 11, **dadurch gekennzeichnet, dass** die inhärent flammfeste Faser aus der Gruppe, bestehend aus einem Aramid, einem Polyamidimid, einem Melamin, einem Polybenzimidazol, einem Polyimid, einem Polyphenylenbenzobisoxazol, einem Polyphenylensulfid, einem Polyetherketon, einem Polyetheretherketon und einer Kombination davon, ausgewählt ist.

13. Gewebe nach einem der Ansprüche 10 bis 12, **dadurch gekennzeichnet, dass** die inhärent flammfeste Faser ein Polybenzimidazol ist.

14. Gewebe nach einem der Ansprüche 10 bis 13, **dadurch gekennzeichnet, dass** es 45 bis 55 Gew.-% der Micro-Denier-Aramidfaser umfasst.

15. Gewebe nach einem der Ansprüche 10 bis 14, **dadurch gekennzeichnet, dass** es 25 bis 35 Gew.-% der behandelten Faser umfasst.

16. Gewebe nach einem der Ansprüche 10 bis 15, **dadurch gekennzeichnet, dass** die behandelte Faser flammfeste Cellulose ist.

17. Gewebe nach einem der Ansprüche 10 bis 16, **dadurch gekennzeichnet, dass** die behandelte Faser flammfeste Kunstseide ist.

18. Gewebe nach einem der Ansprüche 10 bis 17, **dadurch gekennzeichnet, dass** die inhärent flammfeste Faser eine PBI-Stapelfaser ist, die Micro-Denier-Aramidfaser eine Micro-Denier-Aramidstapelfaser ist und die behandelte Faser flammfeste Kunstseide ist.

19. Gewebe nach einem der Ansprüche 10 bis 18, **dadurch gekennzeichnet, dass** es einen Taber-Abriebwiderstand von ungefähr 180 Zyklen bis zum Versagen aufweist.

20. Gewebe nach einem der Ansprüche 10 bis 19, **dadurch gekennzeichnet, dass** es einen Taber-Abriebwiderstand von ungefähr 230 Zyklen bis zum Versagen aufweist.

21. Gewebe nach einem der Ansprüche 10 bis 20, **dadurch gekennzeichnet, dass** es eine thermische Schutzleistung pro Gewicht von zumindest 0,059 TTP/GSM (2,0 TPP/OSY) aufweist.

22. Gewebe nach einem der Ansprüche 10 bis 21, **dadurch gekennzeichnet, dass** es eine thermische Schutzleistung pro Gewicht von ungefähr 0,074 TTP/GSM (2,5 TPP/OSY) aufweist.

23. Gewebe nach einem der Ansprüche 10 bis 22, **dadurch gekennzeichnet, dass** es einen logistischen thermischen Lichtbogenschutzwert pro Gewicht von zumindest 0,028 ATPV/GSM (1,0 ATPV/OSY) aufweist.

24. Gewebe nach einem der Ansprüche 10 bis 23, **dadurch gekennzeichnet, dass** es einen logistischen thermischen Lichtbogenschutzwert pro Gewicht von zumindest 0,038 ATPV/GSM (1,28 TPP/OSY) aufweist.

25. Gewebe nach einem der Ansprüche 10 bis 24, **dadurch gekennzeichnet, dass** es eine Weiterreißfestigkeit von zumindest 66,72 x 66,72 N (W x F) [15 x 15 lbf (W x F)] aufweist.

26. Gewebe nach einem der Ansprüche 10 bis 25, **dadurch gekennzeichnet, dass** es eine Weiterreißfestigkeit von ungefähr 86,3 x 92,1 N (W x F) [19,4 x 20,7 lbf (W x F)] aufweist.

27. Gewebe nach einem der Ansprüche 10 bis 26, **dadurch gekennzeichnet, dass** es eine Reißfestigkeit von zumindest 10 x 5 (Tongue) (Single-Rip) aufweist.

28. Gewebe nach einem der Ansprüche 10 bis 27, **dadurch gekennzeichnet, dass** es eine Reißfestigkeit von zumindest 13,1 x 10,0 (Tongue) (Single-Rip) aufweist.

29. Gewebe nach einem der Ansprüche 10 bis 28, **dadurch gekennzeichnet, dass** es eine Zugfestigkeit von zumindest 444,8 x 444,8 N (W x F) [100 x 100 lbf (W x F)] für einen Streifen von 2,54 cm [1 Zoll] aufweist.

30. Gewebe nach einem der Ansprüche 10 bis 29, **dadurch gekennzeichnet, dass** es eine Zugfestigkeit von zumindest 525,3 x 534,7 N (W x F) [118,1 x 120,2 lbf (W x F)] für einen Streifen von 2,54 cm [1 Zoll] aufweist.

Revendications

1. Fil destiné à être utilisé dans des vêtements de protection industriels et ayant de bonnes propriétés de barrière thermique, une bonne durabilité et de bons classements de confort, **caractérisé par le fait qu'**il comprend :

   - 10 à 30 % en poids d'une fibre intrinsèquement résistante aux flammes ;
   - 20 à 60 % en poids d'une fibre d'aramide micro-denier (ayant un denier inférieur à 1 ou 0,1 tex par filament ou un diamètre inférieur à 10 micromètres) ; et
   - 20 à 60 % en poids d'une fibre traitée.

2. Fil selon la revendication 1, **caractérisé par le fait qu'**il comprend 15 à 25 % en poids de ladite fibre intrinsèquement résistante aux flammes.

3. Fil selon la revendication 1 ou la revendication 2, **caractérisé par le fait que** ladite fibre intrinsèquement résistante aux flammes est choisie dans le groupe consistant en un aramide, un polyamide imide, une mélamine, un polybenzimidazole, un polyimide, un poly(phénylène benzobisoxazole), un poly(sulfure de phénylène), une poly(éther cétone), une poly(étheréther cétone) et une combinaison de ceux-ci.

4. Fil selon l'une quelconque des revendications 1 à 3, **caractérisé par le fait que** ladite fibre intrinsèquement résistante aux flammes est un polybenzimidazole.

5. Fil selon l'une quelconque des revendications 1 à 4, **caractérisé par le fait qu'**il comprend 45 à 55 % en poids de ladite fibre d'aramide micro-denier.

6. Fil selon l'une quelconque des revendications 1 à 5, **caractérisé par le fait qu'**il comprend 25 à 35 % en poids de ladite fibre traitée.

7. Fil selon l'une quelconque des revendications 1 à 6, **caractérisé par le fait que** ladite fibre traitée est une fibre cellulosique retardatrice de flamme.

8. Fil selon l'une quelconque des revendications 1 à 7, **caractérisé par le fait que** ladite fibre traitée est une rayonne retardatrice de flamme.

9. Fil selon l'une quelconque des revendications 1 à 8, **caractérisé par le fait que** ladite fibre intrinsèquement résistante aux flammes est un brin de PBI, ladite fibre d'aramide micro-denier est un brin d'aramide micro-denier et ladite fibre traitée est une rayonne retardatrice de flamme.

10. Tissu destiné à être utilisé dans des vêtements de protection industriels et ayant de bonnes propriétés de barrière thermique, une bonne durabilité et de bons classements de confort, **caractérisé par le fait qu'**il comprend :

    - 10 à 30 % en poids d'une fibre intrinsèquement résistante aux flammes ;
    - 20 à 60 % en poids d'une fibre d'aramide micro-denier (ayant un denier inférieur à 1 ou 0,1 tex par filament ou un diamètre inférieur à 10 micromètres) ; et
    - 20 à 60 % en poids d'une fibre traitée.

11. Tissu selon la revendication 10, **caractérisé par le fait qu'**il comprend 15 à 25 % en poids de ladite fibre intrinsèquement résistante aux flammes.

12. Tissu selon la revendication 10 ou la revendication 11, **caractérisé par le fait que** ladite fibre intrinsèquement résistante aux flammes est choisie dans le groupe consistant en un aramide, un polyamide imide, une mélamine, un polybenzimidazole, un polyimide, un poly(phénylène benzobisoxazole), un poly(sulfure de phénylène), une poly (éther cétone), une poly(étheréther cétone) et une combinaison de ceux-ci.

13. Tissu selon l'une quelconque des revendications 10 à 12, **caractérisé par le fait que** ladite fibre intrinsèquement résistante aux flammes est un polybenzimidazole.

14. Tissu selon l'une quelconque des revendications 10 à 13, **caractérisé par le fait qu'**il comprend de 45 à 55 % en poids de ladite fibre d'aramide micro-denier.

15. Tissu selon l'une quelconque des revendications 10 à 14, **caractérisé par le fait qu'**il comprend 25 à 35 % en poids de ladite fibre traitée.

16. Tissu selon l'une quelconque des revendications 10 à 15, **caractérisé par le fait que** ladite fibre traitée est une fibre cellulosique retardatrice de flamme.

17. Tissu selon l'une quelconque des revendications 10 à 16, **caractérisé par le fait que** ladite fibre traitée est une rayonne retardatrice de flamme.

18. Tissu selon l'une quelconque des revendications 10 à 17, **caractérisé par le fait que** ladite fibre intrinsèquement résistante aux flammes est un brin de PBI, ladite fibre d'aramide micro-denier est un brin d'aramide micro-denier et ladite fibre traitée est une rayonne retardatrice de flamme.

19. Tissu selon l'une quelconque des revendications 10 à 18, **caractérisé par le fait qu'**il a une résistance à l'abrasion de Taber d'au moins 180 cycles jusqu'à la rupture.

20. Tissu selon l'une quelconque des revendications 10 à 19, **caractérisé par le fait qu'**il a une résistance à l'abrasion de Taber d'approximativement 230 cycles jusqu'à la rupture.

21. Tissu selon l'une quelconque des revendications 10 à 20, **caractérisé par le fait qu'**il a une performance de

protection thermique en poids d'au moins 0,059 TPP/GSM (2,0 TPP/OSY).

22. Tissu selon l'une quelconque des revendications 10 à 21, **caractérisé par le fait qu'**il a une performance de protection thermique en poids d'approximativement 0,074 TPP/GSM (2,5 TPP/OSY).

23. Tissu selon l'une quelconque des revendications 10 à 22, **caractérisé par le fait qu'**il a une valeur logistique de performance à l'arc thermique en poids d'au moins 0,028 ATPV/GSM (1,00 ATPV/OSY).

24. Tissu selon l'une quelconque des revendications 10 à 23, **caractérisé par le fait qu'**il a une valeur logistique de performance à l'arc thermique en poids d'approximativement 0,038 ATPV/GSM (1,28 ATPV/OSY).

25. Tissu selon l'une quelconque des revendications 10 à 24, **caractérisé par le fait qu'**il a une résistance à la déchirure d'au moins 66,72 x 66,72 N (W x F) [15 x 15 livres-force (W x F)].

26. Tissu selon l'une quelconque des revendications 10 à 25, **caractérisé par le fait qu'**il a une résistance à la déchirure d'approximativement 86,3 x 92,1 N (W x F) [19,4 x 20,7 livres-force (W x F)].

27. Tissu selon l'une quelconque des revendications 10 à 26, **caractérisé par le fait qu'**il a une résistance à la déchirure d'au moins 10 x 5 (languette) (déchirure simple).

28. Tissu selon l'une quelconque des revendications 10 à 27, **caractérisé par le fait qu'**il a une résistance à la déchirure d'approximativement 13,1 x 10,0 (languette) (déchirure simple).

29. Tissu selon l'une quelconque des revendications 10 à 28, **caractérisé par le fait qu'**il a une résistance à la traction d'au moins 444,8 x 444,8 N (W x F) [100 x 100 livres-force (W x F)] pour une bande de 1 pouce.

30. Tissu selon l'une quelconque des revendications 10 à 29, **caractérisé par le fait qu'**il a une résistance à la traction d'approximativement 525,3 x 534,7 N (W x F) [118,1 x 120,2 livres-force (W x F)] pour une bande de 1 pouce.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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