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(71) Applicant: **MILLIKEN & COMPANY** [US/US]; 920 Milliken Road (M-495), Spartanburg, South Carolina 29303 (US).

(72) Inventors: **LI, Shulong**; 204 Woodgrove Trace, Spartanburg, South Carolina 29301 (US). **DARNELL, Ryan**; 5 Still Creek Court, Greer, South Carolina 29651 (US). **TIDD, IV, Charles R.**; 103 Deer Spring Lane, Simpsonville, South Carolina 29680 (US).

(74) Agent: **BRICKEY, Cheryl J.**; 920 Milliken Road (M-495), Spartanburg, South Carolina 29303 (US).

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(54) Title: TEXTILE MATERIALS CONTAINING YARNS WITH AN INTIMATE BLEND OF ARAMID FIBERS AND POLYPHENYLENE SULFIDE FIBERS

(57) Abstract: The invention provides a woven textile having a first and second side and comprising a plurality of yarns, wherein at least a portion of the yarns comprise an intimate blend of at least about 51% by weight polyphenylene sulfide fibers, less than about 49% by weight para-aramid fibers, and, less than about 2% by weight meta-aramid fibers. The polyphenylene sulfide, para-aramid, and meta-aramid fibers are staple fibers with an average staple fiber length of between about 20 and 100 mm.



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TEXTILE MATERIALS CONTAINING YARNS WITH AN INTIMATE BLEND OF ARAMID FIBERS AND POLYPHENYLENE SULFIDE FIBERS

TECHNICAL FIELD OF THE INVENTION

[0001] This application relates to textile materials containing yarns that have an intimate blend of aramid fibers and polyphenylene sulfide fibers and garments made from these textile materials.

BACKGROUND

[0002] Polyphenylene sulfide is a thermoplastic polymer that exhibits many desirable properties. For example, polyphenylene sulfide (PPS) exhibits resistance to heat, various chemicals (e.g., acids, alkalis, and bleaches), mildew, aging, UV exposure (e.g., sunlight), and abrasion. Due to its thermoplastic nature and the desirable properties, polyphenylene sulfide polymer has been extruded into fibers suitable for use in making textile materials. These polyphenylene sulfide fibers have been used in industrial textile materials, such as high temperature filtration media and automotive hose reinforcement, for many years.

[0003] There is a need for a textile material that contains both PPS fibers and aramid fibers to produce a fire resistant textile.

BRIEF SUMMARY OF THE INVENTION

[0004] In a first embodiment, the invention provides a woven textile having a first and second side and comprising a plurality of yarns, wherein at least a portion of the yarns comprise an intimate blend of at least about 51% by weight polyphenylene sulfide fibers, less than about 49% by weight para-aramid fibers, and, less than about 2% by weight meta-aramid fibers. The polyphenylene sulfide, para-aramid, and meta-aramid fibers are staple fibers with an average staple fiber length of between about 20 and 100 mm.

DETAILED DESCRIPTION OF THE INVENTION

[0005] In a first embodiment, the invention provides a textile material comprising yarns, the yarns comprising a intimate blend of a plurality of aramid fibers and a plurality of polyphenylene sulfide fibers (PPS fibers). By "yarn" is meant an assemblage of fibers spun or twisted together to form a continuous strand, which can be used in weaving, knitting, braiding, or plaiting, or otherwise made into a textile material or fabric. The textile material of this first embodiment can take any suitable form. For example, the plurality of polyphenylene sulfide fibers and aramid fibers can be consolidated to provide a yarn. In such an embodiment, the yarn can contain other fibers in addition to the polyphenylene sulfide fibers and aramid fibers, as is described in further detail below. In another embodiment, the plurality of aramid fibers and polyphenylene sulfide fibers can be consolidated into a nonwoven textile material.

[0006] The textile material can also be a woven textile material comprising a plurality of interlaced yarns, at least one of which contains the aramid fibers and polyphenylene sulfide fibers. Preferably, the textile material is a woven textile. Preferably the woven textile is in a plain weave construction. Preferably, the plain weave has a warp direction and a weft direction and between 30 and 70 ends and picks per inch in both the warp and weft directions.

[0007] The textile material can also be a knit textile material comprising one or more interlooped yarns, at least one of which contains the aramid fibers and polyphenylene sulfide fibers. Preferably, the weight range of the textile material is between about 2.5 and 20 oz/yd², more preferably between about 4 and 12 oz/yd².

[0008] The polyphenylene sulfide fibers can comprise any suitable polyphenylene sulfide polymer. The polyphenylene sulfide polymer can have any suitable molar mass. Preferably, the polyphenylene sulfide polymer has a mass average molar mass of about 20,000 g/mol or more. More preferably, the polyphenylene sulfide polymer has a mass average molar mass of about 30,000 g/mol or more, about 40,000 g/mol or more, or about 50,000 g/mol or more. Preferably, the polyphenylene sulfide polymer has a mass average molar mass of about 100,000 g/mol or less. More preferably, the polyphenylene sulfide polymer has a mass average molar mass of about 80,000 g/mol or less, about 70,000 g/mol

or less, or about 60,000 g/mol or less. In a particularly preferred embodiment, the polyphenylene sulfide polymer has a mass average molar mass of about 40,000 g/mol to about 60,000 g/mol. The polyphenylene sulfide polymer can have any suitable melt viscosity. Preferably, the polyphenylene sulfide polymer has a melt viscosity of about 1,000 poise or more when measured at 300 °C and an apparent shear rate of 400 s⁻¹ in accordance with ASTM Test Method 3835. More preferably, the polyphenylene sulfide polymer has a melt viscosity of about 1,000 poise to about 3,000 poise or about 1,000 poise to about 2,200 poise when measured as described above.

[0009] The polyphenylene sulfide polymer can exhibit any suitable degree of crystallinity. Preferably, the percent crystallinity of the polyphenylene sulfide polymer is 10% or more. More preferably, the percent crystallinity of the polyphenylene sulfide polymer is about 20% or more, about 25% or more, or about 30% or more. The percent crystallinity of the polyphenylene sulfide polymer preferably is about 80% or less. More preferably, the percent crystallinity of the polyphenylene sulfide polymer is about 75% or less. Thus, in a series of preferred embodiments, the percent crystallinity of the polyphenylene sulfide polymer is from 10% to about 80%, about 20% to about 80%, or about 30% to about 75%.

[0010] The yarns contain aramid fibers, preferably para-aramid fibers. The most well-known para-aramid fibers are available as KEVLAR® available from DuPont. Other suitable commercial products of para-aramid fiber include TWARON™ and TECHNORA™ by Teijin Aramid B.V. Para-aramid have been shown to have good flame characteristics and produce textile materials having desired strength and fire resistance properties.

[0011] The yarns preferably comprise a blend of a plurality of aramid fibers and a plurality of polyphenylene sulfide fibers. In one embodiment, the textile material comprises at least about 50% by weight yarns that contain a plurality of aramid fibers and polyphenylene sulfide fibers, more preferably at least about 60%, at least about 70%, at least about 90%, and at least about 95% by weight. The polyphenylene sulfide and aramid fibers may have any suitable denier, preferably between 1 and 8 denier, more preferably between about 1 and 3 denier.

[0012] As used herein, "aramid" is meant a polyamide wherein at least 85% of the amide (--CONH--) linkages are attached directly to two aromatic rings. Additives can be used with the aramid and, in fact, it has been found that up to as much as 10 percent, by weight, of other polymeric material can be blended with the aramid or that copolymers can be used having as much as 10 percent of other diamine substituted for the diamine of the aramid or as much as 10 percent of other diacid chloride substituted for the diacid chloride of the aramid. Suitable aramid fibers are described in *Man-Made Fibers--Science and Technology, Volume 2, Section titled Fiber-Forming Aromatic Polyamides*, page 297, W. Black et al., Interscience Publishers, 1968. Aramid fibers are, also, disclosed in U.S. Pat. Nos. 4,172,938; 3,869,429; 3,819,587; 3,673,143; 3,354,127; and 3,094,511. M-aramid are those aramids where the amide linkages are in the meta-position relative to each other, and p-aramids are those aramids where the amide linkages are in the para-position relative to each other. In the practice of this invention the aramids most often used are poly(paraphenylene terephthalamide) and poly(metaphenylene isophthalamide).

[0013] The intimately blended yarns making up the textile material and the textile material itself can contain any suitable amounts of PPS fibers and para-aramid fibers. Preferably, the plurality of intimately blended yarns and/or the textile material comprise at least about 51% by weight polyphenylene sulfide fibers. In another embodiment, the plurality of intimately blended yarns comprises at least about 55%, at least about 60% or at least about 70% by weight polyphenylene sulfide fibers. In another embodiment, the plurality of intimately blended yarns and/or the textile material comprises between about 20 and 90% by weight polyphenylene sulfide fibers, more preferably between about 60 and 80% weight.

[0014] In another embodiment, the plurality of intimately blended yarns and/or the textile material comprise between about 5 and 70% by weight para-aramid fibers, more preferably between about 10 and 40% weight. In another embodiment, the plurality of intimately blended yarns and/or the textile material contain less than about 49% by weight, more preferably less than about 40%, less than about 35%, or less than about 30% by weight para-aramid fibers.

[0015] In one preferred embodiment, the intimately blended yarns and/or the textile material comprise an intimate blend of between about 60 and 85% by weight polyphenylene sulfide fibers and between about 15 and 40% by weight para-aramid fibers.

[0016] The most well-known meta-aramid fibers are available as NOMEX® available from DuPont. NOMEX® and related aramid polymers are related to nylon, but have aromatic backbones, and hence are more rigid and more durable. NOMEX® is produced by condensation reaction from the monomers *m*-phenylenediamine and isophthaloyl chloride. Preferably, the intimately blended yarns contain less than 2% wt meta-aramid. In another embodiment, the intimately blended yarns contain less than 1% wt meta-aramid fibers, more preferably less than 0.5% wt, more preferably less than 0.1% wt meta-aramid fibers. In one embodiment, the intimate blended yarns contain essentially no meta-aramid fibers, defined in this application to be less than 0.05% wt meta-aramid fibers. In another embodiment, the textile material (as a whole) contains less than 2% wt meta-aramid fibers. In another embodiment, the textile material contains less than 1% wt meta-aramid, more preferably less than 0.5% wt, more preferably less than 0.1% wt meta-aramid. In one embodiment, the textile material contains essentially no meta-aramid fibers, defined in this application to be less than 0.05% wt meta-aramid fibers.

[0017] Staple fibers for use in spinning yarns are generally of a particular length and of a particular linear density. For use in this invention, the fibers can have any length which is adequate for manufacture of spun yarns. Staple lengths of 20 to 100 millimeters can be used and lengths of but lengths of between about 10 and 200 millimeters could be used. In another embodiment, the fibers making up the yarns have a staple cut length of between about 30 and 60 mm, more preferably between about 38 and 52 mm. The yarn formed from the fibers may be any type of yarn formed by any suitable process. For example, the yarn can be made be a jet spun, open end spun, ring spun, vortex spun yarn, it can be Z type twist or S type twist; can be single ply, 2 ply, 3 ply, etc. Preferably, the yarns are formed by the process of ring spinning. Yarn size preferably ranges from 40 count to 5 count (cotton yarn count system).

[0018] As utilized herein, the term “inherent flame resistant fibers” refers to synthetic fibers which, due to the chemical composition of the material from which they are made, exhibit flame resistance without the need for an additional flame retardant treatment. In one embodiment, the yarns can contain additional inherent flame resistant fibers. In such embodiments, the inherent flame resistant fibers can be any suitable inherent flame resistant fibers, such as polyoxadiazole fibers, polysulfonamide fibers, poly(benzimidazole) fibers, aramid fibers (e.g., *para*-aramid fibers), polypyridobisimidazole fibers, polybenzylthiazole fibers, polybenzylloxazole fibers, melamine-formaldehyde polymer fibers, phenol-formaldehyde polymer fibers, oxidized polyacrylonitrile fibers, polyamide-imide fibers and combinations, mixtures, or blends thereof. In a preferred embodiment, the textile material comprises aramid fibers in addition to the polyphenylene sulfide fibers. Other fibers can additionally be included into the textile material concluding polyamidimid fibers, phenol-formaldehyde fibers, melamine fibers, glass fibers, metal fibers, elastomeric fibers/yarns, and carbon fibers. In some embodiments, the elastomeric yarn is a spandex yarn. While in some embodiments the preferred elastomeric fiber yarn is a spandex fiber yarn, any fiber generally having stretch and recovery can be used. As used herein, “spandex” has its usual definition, that is, a manufactured fiber in which the fiber-forming substance is a long chain synthetic polymer composed of at least 85% by weight of a segmented polyurethane. The textile material may also, in some embodiments, comprise a core spun yarn which is a mono or multifilament core covered with a fiber covering.

[0019] The textile materials described above are believed to be well-suited for use in applications where the textile material must meet certain requirements for flame resistance. For example, the textile material can be a fabric used in the manufacture of curtains or window treatments, which fabric should meet the most stringent requirements of NFPA 701. The textile material can also be used in the manufacture of upholstery and furniture fabrics, automotive fabrics (e.g., woven, knit, or nonwoven textiles used in automotive applications), aircraft interiors, etc. In one embodiment, the textile materials are formed into garments such as pants, shirts, jackets, shoes, attachments onto jackets, belts, hats, and raincoats. According to one embodiment, the garment comprises a structure comprising an internal layer,

optionally an intermediate layer made of a breathing waterproof material, and an outer layer made of the above-described fabric of the invention. In another embodiment, a water and/or vapor resistant layer may be adhered to the textile material.

[0020] The textile material described above can contain other fibers in addition to the polyphenylene sulfide, aramid fibers, and optional additional inherent flame resistant fibers discussed above. In such embodiments, the textile material can further comprise any suitable natural fiber or synthetic fiber or combination of natural fibers and/or synthetic fibers. These additional fibers can be intimately blended with the polyphenylene sulfide and aramid fibers within the textile material. For example, the textile material can be a yarn in which the polyphenylene sulfide and aramid fibers are intimately blended with, for example, cellulosic fibers. Alternatively, the additional fibers and the polyphenylene sulfide and aramid fibers can be present in separate elements within the textile material. For example, the textile material can comprise a first yarn containing the polyphenylene sulfide and aramid fibers and a second yarn containing, for example, cellulosic fibers.

[0021] As noted above, the textile material can comprise any suitable natural or synthetic fiber(s) in addition to the polyphenylene sulfide, aramid fibers, and optional additional inherent flame resistant fibers discussed above. In a preferred embodiment, the textile material further comprises cellulose fibers. The cellulose fibers used in such an embodiment can be natural cellulose fibers (e.g., cotton fibers), regenerated cellulose fibers, or any combination thereof. Suitable regenerated cellulose fibers include, but are not limited to, rayon fibers (e.g., viscose rayon fibers, high wet modulus rayon fibers, modal fibers, and polynosic fibers), lyocell fibers, and mixtures thereof.

[0022] When the textile material comprises cellulose fibers, the textile material can further comprise a flame retardant that is added to improve the flame resistance of the cellulose fibers and the textile material containing the same. In such embodiments, any suitable flame retardant can be used. Preferably, the flame retardant is a phosphorus-based flame retardant, such as the flame retardants based on tetrahydroxymethylphosphonium salts and condensates thereof. Suitable

examples of such flame retardants include, but are not limited to, those flame retardants described in U.S. Patent No. 7,713,891; U.S. Patent No. 8,012,890; U.S. Patent No. 8,012,891; U.S. Patent No. 8,722,551; U.S. Patent No. 9,091,020; U.S. Patent No. 9,453,112; and U.S. Patent Application Publication No. US 2015/0118931 A1, each of which is hereby incorporated by reference.

[0023] The textile material can also comprise synthetic fibers in addition to the polyphenylene sulfide, aramid fibers, and optional additional inherent flame resistant fibers, such as thermoplastic synthetic fibers. Suitable thermoplastic synthetic fibers include, but are not necessarily limited to, polyester fibers (e.g., poly (ethylene terephthalate) fibers, poly (propylene terephthalate) fibers, poly (trimethylene terephthalate) fibers), poly (butylene terephthalate) fibers, and blends thereof, polyamide fibers (e.g., nylon 6 fibers, nylon 6,6 fibers, nylon 4,6 fibers, and nylon 12 fibers), polyvinyl alcohol fibers, and combinations, mixtures, or blends thereof. Preferably, the thermoplastic synthetic fibers are selected from the group consisting of polyester fibers, polypropylene fibers, and mixtures thereof. In another embodiment, the intimately blended yarns (or other yarns within the textile material) may contain antistatic fibers.

[0024] When the textile material comprises thermoplastic synthetic fibers, the textile material can further comprise a flame retardant that is added to improve the flame resistance of the thermoplastic synthetic fibers and the textile material containing the same. Any flame retardant suitable for use with thermoplastic synthetic fibers can be used in such embodiments.

[0025] In a preferred embodiment, the polyphenylene sulfide fibers and the aramid fibers are intimately blended together and formed into yarns. Intimately blended means that the two types of fibers are not formed into separate yarns and then twisted together, but that the yarn contains both polyphenylene sulfide fibers and the aramid fibers entangled with each other. Preferably, the yarns are formed by the process of spinning, wherein the process of spinning is selected from the group consisting of open-end, ring, jet, vortex, rotor-spun, and Siro-spun spinning. Most preferred are the open-end spinning and ring spinning processes. In ring spinning, the ring yarn has consistent fiber orientation. Most of the fibers look to be

oriented to the same angle, so most of the fibers help contribute to the yarn strength. Open end spinning is an alternative to ring spinning. Unlike the fiber orientation seen in ring spun yarns, the fiber orientation in an open end yarn tends to be more random and inconsistent.

[0026] In one embodiment, the polyphenylene sulfide fibers of the textile material are dyed and comprise at least one dye. The dye can be any suitable dye, but disperse dyes are particularly preferred. Preferably, the dye is a disperse dye selected from the group consisting of disperse dyes having a molar mass of about 350 g/mol or more, disperse dyes comprising a nitro group, and mixtures thereof. In another preferred embodiment, the dye is a disperse dye selected from the group consisting of disperse dyes having a molar mass of about 400 g/mol or more, disperse dyes comprising a nitro group, and mixtures thereof. While not wishing to be bound to any particular mechanism or theory, it has been observed that disperse dyes having a higher molar mass (e.g., about 350 g/mol or more or about 400 g/mol or more) and/or a polar nature (such as disperse dyes containing a nitro group) are capable of satisfactorily dyeing the polyphenylene sulfide fibers, whereas disperse dyes that do not possess either of these characteristics are not. For example, it has been observed that dyes that do not possess either of these characteristics do not become sufficiently fixed in the polyphenylene sulfide fiber. With the exception of nitrodiphenylamine disperse dyes, the disperse dye preferably has a boiling point of 590 °C or more, more preferably about 600 °C or more. With the exception of nitrodiphenylamine disperse dyes, the disperse dye preferably has a flash point of 300 °C or more, more preferably about 310 °C or more. In a particular embodiment, the disperse dye has a boiling point of 590 °C or more (e.g., about 600 °C or more) and a flash point of 300 °C or more (e.g., about 310 °C or more).

[0027] The disperse dye can be any suitable disperse dye that possesses one or more of the characteristics described above. In a more specific preferred embodiment, the disperse dye is selected from the group consisting of azo dyes (e.g., azothiophene dyes, azobenzothiazole dyes), diazo dyes, anthraquinone dyes, nitro dyes (e.g., nitrodiphenylamine dyes), quinoline dyes, dibenzofuran dyes, naphthalimide dyes (e.g., aminoketone dyes), and mixtures thereof. Any of the above-mentioned dyes can be used in combination to produce polyphenylene sulfide

fibers and textile materials exhibiting the desired color and shade. More information about dyed PPS fibers can be found in US Patent Application Publication 2019/0338462 which is herein incorporated by reference.

[0028] In one embodiment, further elements can be added to the textile material such as coatings, films, and the like. The textile material has a first and a second side. In one embodiment, at least one of the first and second sides of the textile material have a coating applied thereon. This coating can remain on the surface of the textile material or can soak into the textile and coat the majority of the surfaces of the yarns in the textile. The coating may be any suitable coating such as an adhesive layer, colored layer, or primer layer. In another embodiment, at least one of the first and second sides of the textile material have a film applied thereon. Any suitable method may be used to adhere the film to the textile material including, but not limited to, a separate adhesive layer, an adhesive material in the film, or by incorporating some low-melt fibers into the textile. The film may give additional characteristics or properties to the textile material. In one embodiment, the coating and/or film may further include a flame retardant. The fabric having such coating and/or film thus exhibits flame resistance in accordance with ASTM D6413 test method with less than 2 second afterflame time and less than 4 inches char length.

[0029] In one embodiment, the textile material (and garments made from the textile material) has unusually low laundry shrinkage defined to mean that there is less than about 3% shrinkage according to the AATCC 135 test method after 5 repeated laundry cycles using 140°F hot water for washing cycle. More preferably, the textile material (and garments made from the textile material) have less than about 2% laundry shrinkage according to the same AATCC 135 5 washes test.

[0030] In another embodiment, the textile material has less than about 10% shrinkage after exposed to 2 cal/cm²/sec flame energy for 4 seconds. More preferably, the textile material exhibits less than 5% or less than 3% shrinkage. Source of the flame energy at 2 cal/cm²/sec is available on the standard test equipment described in ASTM F2700 test method.

[0031] The following examples further illustrate the subject matter described above but, of course, should not be construed as in any way limiting the scope thereof.

Example 1

[0032] Intimate fiber blended yarns were made from a blend of 60 % wt meta-aramid and 40% wt para-aramid into 2 ply of 40 count yarns using jet spinning process. The yarns are subsequently autoclaved to thermally set the mechanical dimension for lower laundry shrinkage. The resultant yarns were used as both the warp and weft yarns in a woven fabric with 54 ends and 54 picks per inch in a plain weave construction. The fabric was scoured and heat set in a convection oven at a temperature between 350F and 400F. The woven textile exhibited laundry shrinkage of about 3-4% according to AATCC 135 test method after 5 repeated laundry cycles using 140F hot water for washing cycle.

Example 2

[0033] Intimate fiber blended yarns were made from a blend of 25% para-aramid fiber (Kevlar, 51 mm staple) and 75% PPS fiber (2 denier x 51 mm staple) into 20 count single ply yarns using ring spinning. The resultant yarns were used as both the warp and weft yarns in a woven fabric with 54 ends and 54 picks per inch in a plain weave construction. No autoclave process was used to set the yarns. The resulting fabric was scoured and heat set in a convection oven at a temperature between 350°F and 400°F. The resulting fabric exhibited about 0% shrinkage after exposed to 2 cal/cm²/sec flame energy (from an ASTM F2700 standard test equipment) for 4 seconds.

Example 3

[0034] Intimate fiber blended yarns were made from a blend of 50% para-aramid fiber (Kevlar, 51 mm staple) and 50% PPS fiber (2 denier x 51 mm staple) into 20 count single ply yarns using ring spinning. The resultant yarns were used as both the warp and weft yarns in a woven fabric with 54 ends and 54 picks per inch in a plain weave construction. No autoclave process was used to set the yarns. The

resulting fabric was scoured and heat set in a convection oven at a temperature between 350°F and 400°F. The resulting fabric exhibited about 0% shrinkage after exposed to 2 cal/cm²/sec flame energy (from an ASTM F2700 standard test equipment) for 4 seconds.

[0035] The following table summaries the test results on the textile materials of examples 1-3:

Test	Method	Ex. 1	Ex. 2	Ex. 3
Weight (oz./sq. yd)	ASTM 0-3776	~ 4.0	~ 4.0	~ 4.0
Warp Grab Tensile (lb)	ASTM 0-5034	~ 110	112	82
Fill Grab Tensile (lb)	ASTM 0-5034	~ 130	114	78
Warp Elmandorf Tear (lb)	ASTM 0-1424	6	5.9	4.5
Fill Elmandorf Tear (lb)	ASTM 0-1424	6	5.3	4.2
Warp Shrinkage after laundry (%)*	AATCC 135	~ 3	1.4	-
Fill Shrinkage after laundry (%)*	AATCC 135	~ 2	0	-
Warp Char Length AR (in)	ASTM 0-6413	1.6-2.2	1.8	2.6
Fill Char Length AR (in)	ASTM 0-6413	1.2- 2.2	1.7	2.4
Afterflame (sec)	ASTM 0-6413	0	0	0

* AATCC 135 test method after 5 repeated laundry cycles using 140°F hot water for washing cycle.

Example 4

[0036] A woven fabric made of a warp and a filling yarning yarns. Each of the warp and filling yarn are made using an intimate blend of 93% meta-aramid, 5% para-aramid and 2% Nylon antistatic fibers, in a jet spinning process. The resulting fabric is then heat set in a convection oven at a temperature of about 400°F. The fabric exhibited about 6 -14% shrinkage after exposed to 2 cal/cm²/sec flame energy (from an ASTM F2700 standard test equipment) for 4 seconds.

[0037] As shown in the table above, the of the examples had good flame resistance properties including short char length and zero second afterflame. Example 2 has very small laundry shrinkage compared to the other examples. All of these examples could be further coated or laminated to form finished different flame resistant articles.

[0038] All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

[0039] The use of the terms “a” and “an” and “the” and similar referents in the context of describing the subject matter of this application (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms “comprising,” “having,” “including,” and “containing” are to be construed as open-ended terms (i.e., meaning “including, but not limited to,”) unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., “such as”) provided herein, is intended merely to better illuminate the subject matter of the application and does not pose a limitation on the scope of the subject matter unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the subject matter described herein.

[0040] Preferred embodiments of the subject matter of this application are described herein, including the best mode known to the inventors for carrying out the claimed subject matter. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the subject matter described herein to be practiced otherwise than as specifically described herein. Accordingly, this disclosure includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the present

disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.

WHAT IS CLAIMED IS:

1. A woven textile having a first and second side and comprising a plurality of yarns, wherein at least a portion of the yarns comprise an intimate blend of:
at least about 51% by weight polyphenylene sulfide fibers;
less than about 49% by weight para-aramid fibers; and,
less than about 2% by weight meta-aramid fibers,
wherein the polyphenylene sulfide, para-aramid, and meta-aramid fibers are staple fibers and wherein the staple fibers have an average staple fiber length of between about 20 and 100 mm.
2. The woven textile of claim 1, wherein the woven textile is a plain weave.
3. The woven textile of claim 2, wherein the plain weave has a warp direction and a weft direction and wherein the plain weave has between 30 and 70 ends per inch in both the warp and weft directions.
4. The woven textile of claim 1, wherein the polyphenylene sulfide fibers are dyed.
5. The woven textile of claim 1, wherein the yarns comprise an intimate blend of between about 60 and 85% by weight polyphenylene sulfide fibers and between about 15 and 40% by weight para-aramid fibers.
6. The woven textile of claim 1, wherein the yarns comprise less than about 1% by weight meta-aramid fibers.
7. The woven textile of claim 1, wherein the yarns are formed by the process of ring spinning.
8. The woven textile of claim 1, wherein at least one of the first and second sides comprises a coating.

9. The woven textile of claim 1, wherein at least one of the first and second sides comprises a film.
10. The woven textile of claim 1, wherein at least one of the first and second sides comprises an adhesive.
11. The woven textile of claim 1, wherein yarns further comprise antistatic fibers.
12. The woven textile of claim 1, wherein the woven textile has a wash shrinkage of less than about 3% tested according to the AATCC 135 5 washes cycles procedure.
13. A garment comprising the textile material of claim 1.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/017264

A. CLASSIFICATION OF SUBJECT MATTER
INV. D02G3/04 D03D15/513
ADD.

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)
D02G D03D A41D D01F

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2019/188197 A1 (TORAY INDUSTRIES [JP]) 3 October 2019 (2019-10-03) abstract claims 1,7,9 figure 1 paragraphs [0001] - [0003], [0009], [0024], [0025], [0028], [0031], [0057] - [0067], [0083], [84.107] example 7	1-13
X	US 2019/338462 A1 (LI SHULONG [US] ET AL) 7 November 2019 (2019-11-07) abstract claims 1-3,9-14,22 paragraphs [0001] - [0005], [0014], [0020], [0022], [0025], [0037], [0038], [0056] examples 1,5 ----- -/--	1-5,7-13



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search

19 March 2021

Date of mailing of the international search report

30/03/2021

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Heinzelmann, Eric

INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 104 674 405 A (SHANGHAI TANLON FIBER CO LTD) 3 June 2015 (2015-06-03) abstract claims 1,7-9 paragraphs [0001], [0002], [0005], [0008], [0010] - [0012], [0016], [0018] - [0021], [0024] - [0034], [0063], [0064] - paragraphs [0105], [0118] - [0125], [0178] - [0185] example 2 -----	1-3,5-7, 11,12
X	JP H02 71809 A (TEIJIN LTD) 12 March 1990 (1990-03-12) the whole document -----	1-3,5,7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2021/017264

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