



- (51) **International Patent Classification:**
D02G 3/36 (2006.01) *D02G 3/38* (2006.01)
- (21) **International Application Number:**
PCT/GB2013/050993
- (22) **International Filing Date:**
19 April 2013 (19.04.2013)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
1206956.3 20 April 2012 (20.04.2012) GB
- (71) **Applicant:** COVEC LIMITED [GB/GB]; Chobham Farm, Sandpit Hall Road, Chobham, Surrey GU24 8HA (GB).
- (72) **Inventor:** BLOXSOME, Keith; c/o Covec Limited, Chobham Farm, Sandpit Hall Road, Chobham, Surrey GU24 8HA (GB).
- (74) **Agent:** BINGHAM, Ian; IP Asset LLP, Prama House, 267 Banbury Road, Summertown, Oxford, Oxfordshire OX2 7HT (GB).
- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to the identity of the inventor (Rule 4.17(i))
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))
- of inventorship (Rule 4.17(iv))

[Continued on next page]

- (54) **Title:** THERMOTROPIC LIQUID CRYSTAL POLYMER CORE - SHEATH

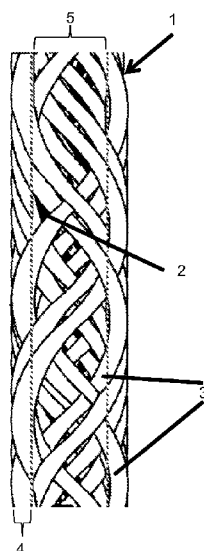


Figure 1A

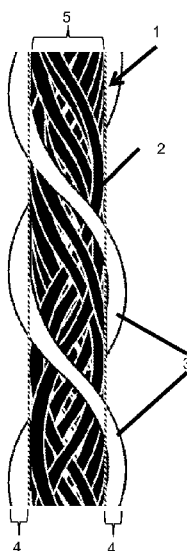


Figure 1B

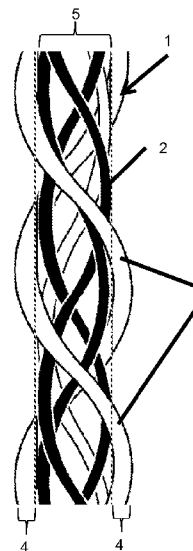


Figure 1C

- (57) **Abstract:** According to a first aspect there is provided a yarn (1) comprising one or more thermotropic liquid crystal polymer fibres (2) blended with one or more further fibres (3), wherein only the further fibres are present in an outer layer (4) of the yarn.



Published:

— with international search report (Art. 21(3))

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

THERMOTROPIC LIQUID CRYSTAL POLYMER CORE - SHEATH

FIELD OF THE INVENTION

The present invention relates to the field of yarns for use in producing textiles. In particular, the present invention relates to improvements in the field of yarns for use in producing technical textiles and to technical textiles comprising such yarns that can be used in the manufacture of clothing.

INTRODUCTION

Technical textiles are a growing sector of the textile industry. Function is normally the primary criterion for a technical textile. Technical textiles include textiles for automotive applications, medical textiles, geotextiles, agrotextiles, and protective clothing. When incorporated into clothing, the use of a technical textile can provide the end user with a clothing item that offers a number of functional advantages – such as abrasion resistance, cut resistance, heat resistance, fire resistance, water resistance and/or burst resistance and the like. Some specific examples include heat and radiation protection for fire fighter clothing, molten metal protection for welders, stab protection, bulletproof vests and spacesuits.

Lyotropic aromatic polyamide fibre, commonly referred to as aramid fibre, has been used in protective apparel. For a lyotropic liquid crystal polymer (LLCP), the liquid crystallinity occurs by dissolving a polymer in a solvent. One well-known lyotropic aromatic polyamide fibre, commercially available under the trade name Kevlar®, is produced by the reaction of terephthalic acid and 1,4-phenylenediamine. While protective articles made with LLCP fibres can exhibit desirable properties, such structures, for example, can exhibit poor cut-resistance and can suffer from hydrolysis and hence poor protection for the end user. Vectran® is a high-performance multifilament fibre spun from a thermotropic liquid crystal polymer (TLCP), wherein, for a thermotropic liquid crystal polymer, liquid crystallinity occurs by heating a polymer above its glass or melting transition point. It is believed to be the only commercially available melt spun liquid crystal polymer fibre in the world. Vectran® fibre exhibits exceptional abrasion resistance, cut resistance and moisture resistance. It has a very low creep, a high melting point and is around five times stronger than steel and ten times stronger than aluminium. It would therefore be desirable to be able to incorporate Vectran® into a technical textile. However, Vectran® is known to be unsuitable for high volume weaving, knitting, cutting, or dying, due to its stiff, harsh and slippery properties and its

almost complete resistance to water (and thus dyes). These properties also make unsuitable for use in clothing.

There is a need in the art for technical textiles offering the features and advantages of thermotropic liquid crystal polymers, particularly for use in the manufacture of clothing.

SUMMARY OF THE INVENTION

According to a first aspect there is provided a yarn comprising one or more thermotropic liquid crystal polymer fibres blended with one or more further fibres, wherein only the further fibres are present in an outer layer of the yarn.

Preferably, both the thermotropic liquid crystal polymer fibres and the further fibres are present within an inner part of the yarn.

The thermotropic liquid crystal polymer fibres can comprise monomer repeat units derived from 4-hydroxybenzoic acid and 6-hydroxy-2-naphthoic acid. Optionally, the thermotropic liquid crystal polymer fibres can comprise Vectran® or a derivative thereof.

The one or more further fibres can be capable of accepting a dye. For example, the one or more further fibres can comprise any of cotton or a derivative thereof, polyester or a derivative thereof; and cotton or a derivative thereof together with polyester or a derivative thereof.

According to a second aspect there is provided a method of producing a yarn. The method comprises blending one or more thermotropic liquid crystal polymer fibres with one or more further fibres such that only the further fibres are present in an outer layer of the yarn.

The thermotropic liquid crystal polymer fibres can comprise monomer repeat units derived from 4-hydroxybenzoic acid and 6-hydroxy-2-naphthoic acid. Optionally, the thermotropic liquid crystal polymer fibres can comprise Vectran® or a derivative thereof.

The one or more further fibres can be capable of accepting a dye. For example, the one or more further fibres can comprise any of cotton or a derivative thereof, polyester or a derivative thereof; and cotton or a derivative thereof together with polyester or a derivative thereof.

The method may further comprise feeding the thermotropic liquid crystal polymer fibres and the one or more further fibres into a spinning machine through an annular mould with only

the further fibres being fed into an outer circumference of the annular mould, and then using the spinning machine to blend the thermotropic liquid crystal polymer fibres and the one or more further fibres.

The method may also further comprise gilling the thermotropic liquid crystal polymer fibres and the one or more further fibres to form a dual-layered bundle of fibres in which only the further fibres are present in a first of the layers, and then feeding the dual-layered bundle into the spinning machine through the annular mould with the first layer of fibres being fed into the outer circumference of the annular mould.

According to a third aspect there is provided a method of manufacturing a textile material. The method comprises manufacturing a yarn using the method according to the second aspect, and weaving or knitting the yarn to form the textile material. The method may further comprise dyeing the textile material. The yarn may be woven or knitted with a further yarn.

According to a fourth aspect there is provided a textile material obtained or obtainable by the method according to the third aspect

According to a fifth aspect there is provided a textile material comprising a yarn obtained or obtainable by the method according to the second aspect.

According to a sixth aspect there is provided a textile material comprising a yarn according to the first aspect.

The present invention will now be more particularly described by way of example only with reference to the accompanying drawings, in which:

Figure 1A illustrates a thermotropic liquid crystal polymer-based yarn;

Figure 1B illustrates the thermotropic liquid crystal polymer-based yarn of Figure 1A in which some of the outer fibres have been removed;

Figure 1C illustrates the thermotropic liquid crystal polymer-based yarn of Figure 1A in which only some of the inner and outer fibres are shown; and

Figure 2 illustrates a transverse cross-section of the thermotropic liquid crystal polymer-based yarn of Figure 1A.

DETAILED DESCRIPTION

The technical terms and expressions used within the scope of this application are generally to be given the meaning commonly applied to them in the art. The word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single step may fulfil the functions of several features recited in the claims. The terms "about", "essentially" and "approximately" in the context of a given numerate value or range refers to a value or range that is within 20%, within 10%, or within 5%, 4%, 3%, 2% or 1% of the given value or range.

The description of this invention is written with respect to fibres. The term "fibre" includes not only conventional single fibres and filaments, but also yarns made from a multiplicity of these fibres. In general, yarns are utilised in the manufacture of apparel, textile materials, fabrics, clothing and the like.

Referring now to Figure 1A, there is shown an embodiment of a thermotropic liquid crystal polymer-based yarn 1 that retains the strength and durability of the thermotropic liquid crystal polymer while allowing the yarn to be draped and dyed. In this embodiment, thermotropic liquid crystal polymer fibres 2 are blended with one or more further fibres 3 (i.e. non-[thermotropic liquid crystal polymer fibres]) such that only the further fibres 3 are present in the outer layer/surface 4 of the resulting yarn 1. To further illustrate this, Figure 1B shows a cutaway of the resulting yarn 1 in which some of the outer fibres have been removed, and Figure 1C is a further cutaway illustration of the resulting yarn 1 in which only some of the inner and outer fibres are shown.

As can be seen in Figures 1B and 1C, in the resulting yarn 1 both the thermotropic liquid crystal polymer fibres 2 and the further fibres 3 are present within the core/inner part 5 of the yarn 1, whilst only the further fibres 3 are present in the outer layer/surface 4. The thermotropic liquid crystal polymer fibres 2 are therefore located entirely within the core 5 of the yarn 1, and the further fibres 3 form an external layer or sheath around the core 5.

Typically, when it is desired to produce a yarn that is a combination of two or more fibres, the fibres will be blended together by twisting/spinning the fibres around one another. This blending will therefore result in a yarn in which the two or more fibres are each distributed throughout the cross-section of the yarn. Consequently, each of the two or more fibres will be present in the outer surface of the yarn.

This is not a problem when blending most types of fibre, such as lyotropic liquid crystal polymer fibres, which can absorb moisture and therefore accept a dye. However, the present inventors recognised that when a thermotropic liquid crystal polymer fibre and one or more further fibres are conventionally blended together, the presence of the thermotropic liquid crystal polymer fibre in the outer surface of the yarn will prevent the resulting yarn from being successfully dyed, due to the almost complete moisture resistance of the thermotropic liquid crystal polymer fibre.

The thermotropic liquid crystal polymer-based yarn described herein overcomes this problem by providing that the thermotropic liquid crystal polymer fibres are excluded from the outer layer of the yarn, such that the inclusion of the thermotropic liquid crystal polymer does not affect the ability of the visible components of the yarn to accept a dye. The thermotropic liquid crystal polymer-based yarn retains all of the desirable properties of the thermotropic liquid crystal polymer fibres, such as their strength and durability, whilst providing that the clearly visible components of the yarn can consist of a fibre that can accept a dye. Furthermore, by blending the different fibres in this way, the presence of the further fibres in both the outer layer and the inner part of the yarn improves the drapeability of a textile material that is manufactured from the resulting yarn.

Thermotropic liquid crystal polymers include aromatic polyesters, aliphatic-aromatic polyesters, aromatic polyesteramides, aliphatic-aromatic polyesteramides, aromatic polyesterimides, aromatic polyestercarbonates, aromatic polyamides, aliphatic-aromatic polyamides and polyazomethines. Thermotropic liquid crystal polymers may be aromatic polyesters and/or polyesteramide which form liquid crystalline melt phases at temperatures of less than about 360°C and optionally include one or more monomer units derived from terephthalic acid, isophthalic acid, 1,4-hydroquinone, resorcinol, 4,4'-dihydroxybiphenyl, 4,4'-biphenyldicarboxylic acid, 4-hydroxybenzoic acid, 6-hydroxy-2-naphthoic acid, 2,6-naphthalenedicarboxylic acid, 2,6-dihydroxynaphthalene, 4-aminophenol, and 4-aminobenzoic acid. Some of the aromatic groups may include substituents which do not react under the conditions of the polymerization, such as lower alkyl groups having 1 to 4 carbons and/or aromatic groups.

Suitably, the liquid crystalline polyester comprises, consists of consists essentially of monomer repeat units derived from 4-hydroxybenzoic acid and 6-hydroxy-2-naphthoic acid, as taught in US 4,161,470. Suitably, monomer units derived from 4-hydroxybenzoic acid comprise about 15% to about 85% of the polymer on a mole basis, and monomer units derived from 6-hydroxy-2-naphthoic acid comprise about 85% to about 15% of the polymer

on a mole basis. More suitably, the polymer comprises about 73% monomer units derived from 4-hydroxybenzoic acid and about 27% monomer units derived from 6-hydroxy-2-naphthoic acid, on a mole basis. This polymer is available in fibre form under the VECTRAN® trademark from Kuraray Co. Ltd., Japan. Therefore, in one embodiment, the thermotropic liquid crystal polymer is Vectran®.

Various types of Vectran® are available. The thermotropic liquid crystal polymer fibre can therefore be Vectran®HT, Vectran®HM, or Vectran®UM or a combination thereof. Vectran® HT fibre offers benefits for applications requiring high strength, vibration damping, low moisture absorption, and low CTE. Vectran® NT fibre is a high modulus thermoplastic matrix fibre for applications requiring high impermeability, excellent property retention over a broad temperature range, and low moisture absorption. Vectran® UM offers the highest modulus without sacrificing tensile strength. The basic physical properties comprise of a high tensile strength, high modulus high cut and high abrasion resistance. Vectran® can be filament or spun, and can be extruded in to multiple denier. In one embodiment, the thermotropic liquid crystal polymer fibres can comprise Vectran® 1670 denier, 600 filament fibres.

The thermotropic liquid crystal polymer can be stretch broken in a traditional stretch breaking manor and using stretch braking apparatus that are known in the art. Stretch breaking stretches the thermotropic liquid crystal polymer which is then spun to increase its original tensile strength and elasticity. This also decreases the break strength, break strength being the point of break of the maximum tensile load. The thermotropic liquid crystal polymer fibre is then be blended with one or more further fibres. The one or more further fibres are synthetic or natural fibres or a combination thereof, and are preferably fibres that are capable of accepting a dye.

By way of example, the further fibres could comprise one or more synthetic fibres such as nylon, modacrylic, olefin, acrylic, polyester, carbon fibre and the like and derivatives thereof. In one embodiment, the synthetic fibre that is used is polyester – such as 2.4 dtex polyester or is derived therefrom. Alternatively, or in addition, the further fibres could comprise one or more natural fibres such as alpaca, cashmere, catgut, llama, silk, wool, bamboo, cotton, flax, linen, hemp and the like and derivatives thereof. In one embodiment, cotton or a derivative thereof is used. In another embodiment, cotton or a derivative thereof is used together with a synthetic fibre – such as polyester or a derivative thereof.

Following optional stretch breaking, the further fibres are cut and gilled (for example, carded and combed) which effectively turns the fibres in to slivers for the purpose of blending the

thermotropic liquid crystal polymer fibre and the further fibres. A gill box machine can be used for gilling. As understood in the art, a gill box machine is a machine comprising gills for drafting and combing fibres or filaments. It carries out the gilling process of making the fibres parallel while combing.

The thermotropic liquid crystal polymer and the further fibre(s) are then blended together such that the further fibre(s) form a coating substantially or completely over or around the thermotropic liquid crystal polymer such that the thermotropic liquid crystal polymer fibre is excluded from the outer layer of the yarn.

One possible method by which this blend can be achieved is by feeding slivers of the thermotropic liquid crystal polymer and slivers of the further fibre(s) slivers into an adapted gill box machine where the slivers are separately gilled to form tops (i.e. a bundle of long fibres in a form ready for spinning) until the last stage of gilling, where the separate tops come together, with the slivers of the further fibre(s) on top of the slivers of the thermotropic liquid crystal polymer fibres and subsequently partly blended to form a dual-layered tops ready for spinning.

Advantageously, the dual-layered tops is then fed to an open end spinning machine through a circular mould, forming a circular formed tops, with the further fibre(s) on the outside. In the open end spinning machine, an air jet blows the tops into a rotor of the spinning machine, and both loosens and straightens the fibres. Once within the rotor, the fibres are spun into yarn in the same order as they enter the rotor, such that only the further fibre(s) are on the outside of the yarn. In other words, the thermotropic liquid crystal polymer fibres and the further fibre(s) are blended so that the thermotropic liquid crystal polymer is excluded from the core of the resulting yarn.

Depending upon the use, the yarn can optionally be further processed to produce a textile material, suitably, by weaving or knitting. In one embodiment, the yarn is infused with cotton or a derivative thereof to replicate the natural look of denim.

In certain embodiments, the thermotropic liquid crystal polymer is completely coated or wrapped such that 100% of the thermotropic liquid crystal polymer is located inside the thermotropic liquid crystal polymer-based yarn and 100% of the further fibre(s) are located outside. In certain embodiments, the coating or wrapping may not be entirely complete such that at least some parts of the thermotropic liquid crystal polymer may still be visible or accessible to the outside of the thermotropic liquid crystal polymer-based yarn. Thus, for

example, at least 1%, 2%, 3%, 4%, 5%, 10%, 15% or 20% or more of the thermotropic liquid crystal polymer may still be visible or accessible to the outside of the thermotropic liquid crystal polymer-based yarn.

Various amounts of the thermotropic liquid crystal polymer fibre can be used to prepare the thermotropic liquid crystal polymer-based yarn described herein. In one embodiment, between about 15% to about 90% thermotropic liquid crystal polymer fibre is used – such as between about 20% and about 90% or between about 20% and 80%. In another embodiment, between about 15% and about 30% is used – such as between about 15% and about 25%, or between about 20% and about 25%. In another embodiment, between about 70% to about 90% is used – such as between about 75% to about 85%. In another embodiment, between about 20% and 25% is used – such as about 21%, 22%, 23%, 24% or about 25%. In another embodiment, between about 75% and 85% is used – such as about 75%, 76%, 77%, 78%, 79%, 90%, 81%, 82%, 83%, 84% or 85%. In another embodiment, between about 45% and 55% is used – such as about 45%, 46%, 47%, 48%, 49%, 50%, 51%, 52%, 53%, 54% or 55%.

Various amounts of the further fibre(s) can be blended with the thermotropic liquid crystal polymer-based yarn described herein. In one embodiment, the thermotropic liquid crystal polymer-based yarn comprises, consists or consists essentially of between about 10% to about 60% of the further fibre(s) – such as between about 10% to about 50%, between about 10% to about 40%, between about 10% to about 30%, between about 15% to about 30%, or between about 20% to about 30%. In another embodiment, between about 40% to about 60% of the further fibre(s) are used – such as between about 45% to about 55%, between about 46% to about 55%, between about 47% to about 55%, between about 48% to about 53%, or between about 49% to about 51%.

Any of the amounts of the thermotropic liquid crystal polymer and the further fibre(s) recited above can be combined to prepare the thermotropic liquid crystal polymer-based yarn described herein provided that the total composition of the thermotropic liquid crystal polymer and the further fibre(s) totals 100%. In one embodiment, about 80% of the thermotropic liquid crystal polymer fibres and about 20% of the further fibre(s) are used. In another embodiment, about 50% of the thermotropic liquid crystal polymer fibre and about 50% of the further fibre(s) are used. In another embodiment, between about 50% and about 80% of the thermotropic liquid crystal polymer and between about 20% and 50% of the further fibre(s) are used provided that the total composition is 100%.

In one embodiment, the further fibre is cotton or a fibre comprising cotton or a derivative thereof. Suitably, the amount of the further fibre will be between about 40% and 60% - such as between about 45% and about 60% or about 50% and about 60% or between about 52% and about 58% or between about 52% and about 56% - such as about 54%.

In certain embodiments, the thermotropic liquid crystal polymer-based yarn comprises: (i) between about 15% to about 90% stretch broken thermotropic liquid crystal polymer fibre—such as between about 20% and about 90% or between about 20% and 80%; or between about 15% and about 30% thermotropic liquid crystal polymer fibre – such as between about 15% and about 25%, or between about 20% and about 25%; or between about 70% to about 90% thermotropic liquid crystal polymer fibre - such as between about 75% to about 85%; or between about 20% and 25% thermotropic liquid crystal polymer fibre – such as about 21%, 22%, 23%, 24%; or between about 75% and 85% is used – such as about 75%, 76%, 77%, 78%, 79%, 90%, 81%, 82%, 83%, 84% or 85%; or between about 45% and 55% thermotropic liquid crystal polymer fibre – such as about 45%, 46%, 47%, 48%, 49%, 50%, 51%, 52%, 53%, 54% or 55%; (ii) between about 10% to about 60% the further fibre(s) – such as between about 10% to about 50%, between about 10% to about 40%, between about 10% to about 30%, between about 15% to about 30%, or between about 20% to about 30%; or between about 40% to about 60% of the further fibre(s) – such as between about 45% to about 55%, between about 46% to about 55%, between about 47% to about 55%, between about 48% to about 53%, or between about 49% to about 51%; and (iii) a further fibre incorporated or infused therein – such as between about 40% and 60%, between about 45% and about 60% or between about 50% and about 60% or between about 52% and about 58% or between about 52% and about 56% - such as about 54%.

In one embodiment, the thermotropic liquid crystal polymer-based yarn is further processed to produce a textile material by weaving with a synthetic fibre, such as polyester. The synthetic fibre can be located in either the weft or the warp of the woven textile material.

In one embodiment, the thermotropic liquid crystal polymer-based yarn is further processed to produce a textile material by weaving with a natural fibre, such as cotton. The natural fibre can be located in either the warp or the weft.

The thermotropic liquid crystal polymer-based yarn described herein can be used to produce protective clothing, including protective clothing for motorcyclists. Other applications include clothing for the military for the prevention and minimisation of injuries and clothing for fire-fighters and the like.

The following examples illustrate embodiments of thermotropic liquid crystal polymer-based yarn described herein.

Example 1

A thermotropic liquid crystal polymer-based yarn was developed using 80% Vectran® HT blended with 20% natural white, semi-dull, 2.4dtex polyester. The resulting yarn was then used to develop a twill denim fabric with a final composition of approximately 36% Vectran® HT blended with 10% polyester in the weft and 54% cotton in the warp.

Example 2

A thermotropic liquid crystal polymer-based yarn was developed using 50% Vectran® HT blended with 50% natural white, semi-dull, 2.4dtex polyester. The resulting yarn was then used to develop a twill denim fabric with a final composition of approximately 23% Vectran® HT blended with 23% polyester in the weft and 54% cotton in the warp.

Example 3

A thermotropic liquid crystal polymer-based yarn was developed using 80% Vectran® HT blended with 20% natural white, semi-dull, 2.4dtex polyester. The resulting yarn was then used to develop a twill denim fabric with a final composition of 50% of the thermotropic liquid crystal polymer-based yarn composition described above and 50% cotton.

The fabrics described in the examples given above were found to retain many of the features of Vectran® whilst increasing the flexibility of its uses. The use of the thermotropic liquid crystal polymer-based yarn allowed these fabrics to be successfully dyed and used as a single layer garment that is extremely strong. In particular, these fabrics are suitable for providing a normal denim jeans finish and feel in different grades.

It will be appreciated that although the invention has been described in terms of preferred embodiments as set forth above, it should be understood that these embodiments are illustrative only. Those skilled in the art will be able to make modifications and alternatives in view of the disclosure which are contemplated as falling within the scope of the appended claims.

CLAIMS

1. A yarn (1) comprising one or more thermotropic liquid crystal polymer fibres (2) blended with one or more further fibres (3), wherein only the further fibres (3) are present in an outer layer (4) of the yarn (1).
2. A yarn (1) according to claim 1, wherein the thermotropic liquid crystal polymer fibres (2) and the further fibres (3) are present within an inner part (5) of the yarn (1).
3. A yarn (1) according to any of claims 1 or 2, wherein the one or more further fibres (3) are capable of accepting a dye.
4. A yarn (1) according to any preceding claim, wherein the thermotropic liquid crystal polymer fibres (2) comprises monomer repeat units derived from 4-hydroxybenzoic acid and 6-hydroxy-2-naphthoic acid.
5. A yarn (1) according to claim 4, wherein the thermotropic liquid crystal polymer fibres (2) comprises Vectran® or a derivative thereof.
6. A yarn (1) according to any preceding claim, wherein the one or more further fibres (3) comprise any of
 - i) cotton or a derivate thereof;
 - ii) polyester or a derivate thereof; and
 - iii) cotton or a derivate thereof and polyester or a derivate thereof.
7. A method of producing a yarn, the method comprising blending one or more thermotropic liquid crystal polymer fibres with one or more further fibres such that only the further fibres are present in an outer layer of the yarn.
8. A method according to claim 7, wherein the one or more further fibres are capable of accepting a dye.
9. A method according to any of claims 7 or 8, wherein the thermotropic liquid crystal polymer fibres comprise monomer repeat units derived from 4-hydroxybenzoic acid and 6-hydroxy-2-naphthoic acid.
10. A method according to any of claims 7 to 9, wherein the thermotropic liquid crystal polymer fibre comprises Vectran® or a derivative thereof.

11. A method according to any of claims 7 to 10, wherein the one or more further fibres comprise any of
cotton or a derivate thereof;
polyester or a derivate thereof; and
cotton or a derivate thereof and polyester or a derivate thereof.
12. A method according to any of claims 7 to 11, and comprising:
feeding the thermotropic liquid crystal polymer fibres and the one or more further fibres into a spinning machine through an annular mould with only the further fibres being fed into an outer circumference of the annular mould; and
using the spinning machine to blend the thermotropic liquid crystal polymer fibres and the one or more further fibres.
13. A method according to claim 12, and further comprising:
gilling the thermotropic liquid crystal polymer fibres and the one or more further fibres to form a dual-layered bundle of fibres in which only the further fibres are present in a first of the layers;
feeding the dual-layered bundle into the spinning machine through the annular mould with the first layer of fibres being fed into the outer circumference of the annular mould.
14. A method of manufacturing a textile material, the method comprising:
manufacturing a yarn using the method according to any of claims 7 to 13; and
weaving or knitting the yarn to form the textile material.
15. A method according to claim 14, wherein the yarn is woven or knitted with a further yarn.
16. A method according to any of claims 14 or 15, and further comprising dyeing the textile material.
17. A textile material obtained or obtainable by the method of any of claims 14 to 16.
18. A textile material comprising a yarn obtained or obtainable by the method of any of claims 7 to 13.
19. A textile material comprising a yarn according to any of claims 1 to 6.

1/2

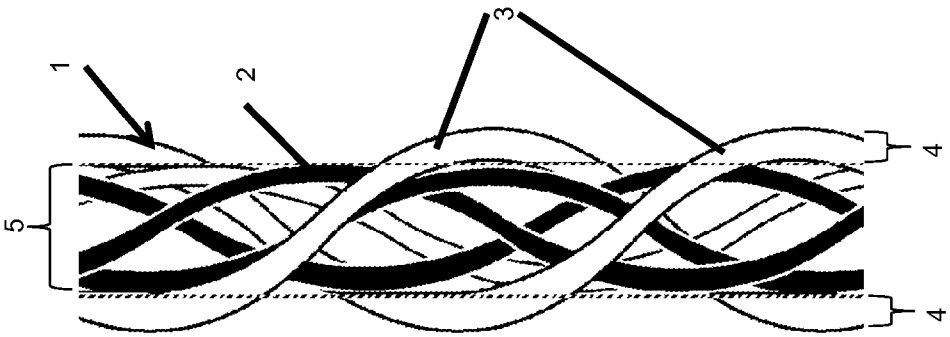


Figure 1C

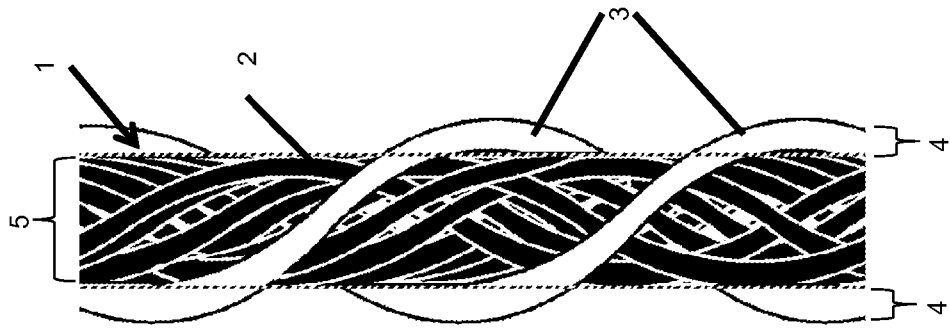


Figure 1B

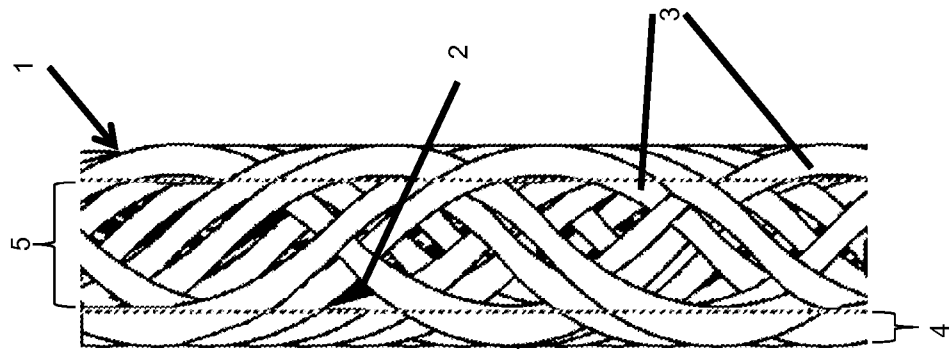
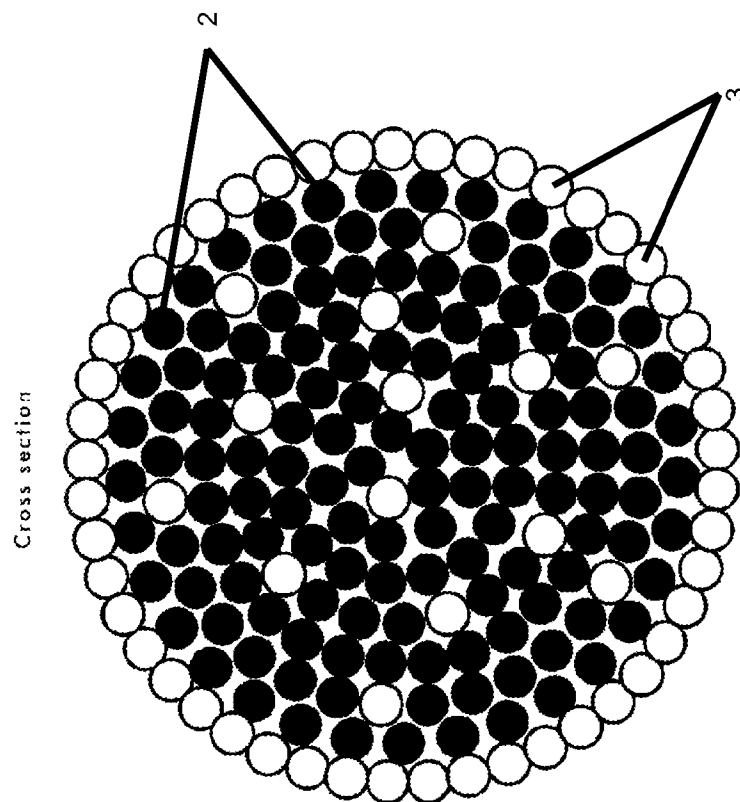


Figure 1A

2/2

Figure 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050993

A. CLASSIFICATION OF SUBJECT MATTER
INV. D02G3/36 D02G3/38
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 F41H A41D D03D D04B

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	US 2005/186875 A1 (LILANI HARISH N [US]) 25 August 2005 (2005-08-25) paragraph [0013]; figure 1 paragraph [0018]; claims 1,2,9; figure 2 -----	1-3,7,8, 14-19
X	JP 2003 138410 A (TORAY DU PONT KK) 14 May 2003 (2003-05-14) paragraph [0006] - paragraph [0007]; figures 1-3 paragraph [0011] paragraph [0001] paragraph [0018] - paragraph [0020] -----	1,3-11, 14-19
X	US 6 279 305 B1 (HUMMEL JOSEPH [US]) 28 August 2001 (2001-08-28) column 3, line 41 - column 4, line 45; figures 1-2,7 column 5, line 6 - line 9 ----- -/-	1,3-11, 14-19

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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

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

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

7 August 2013

Date of mailing of the international search report

20/08/2013

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

Pollet, Didier

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2013/050993

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 458 343 A1 (BETTCHEr INDUSTRIES [US]) 27 November 1991 (1991-11-27) column 6, line 2 - line 37; figures 2,4 -----	1,3-11, 14-19
X	US 2005/155336 A1 (ROBINS STEVEN D [US]) 21 July 2005 (2005-07-21) paragraph [0051] - paragraph [0055]; figures 1,2,4 paragraph [0057] - paragraph [0059] paragraph [0064] -----	1,3-5, 7-10, 14-19

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2013/050993

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005186875	A1	25-08-2005	NONE
JP 2003138410	A	14-05-2003	NONE
US 6279305	B1	28-08-2001	US 6279305 B1 28-08-2001 US 6826898 B1 07-12-2004
EP 0458343	A1	27-11-1991	CA 2043062 A1 26-11-1991 DE 69121772 D1 10-10-1996 DE 69121772 T2 03-04-1997 EP 0458343 A1 27-11-1991
US 2005155336	A1	21-07-2005	NONE