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(54) **Title:** FILAMENT OF RECYCLED POLYPROPYLENE FOR PILE YARN

(57) **Abstract:** A filament for a pile yarn. The filament is a multi-component filament, comprising a core (10), at least a first sheath (20) at least partly enclosing the core (10) and optionally a second sheath (30) at least partly enclosing the first sheath (20). The core (10) comprises recycled polypropylene, and the first sheath (20) comprises polypropylene and a particulate, opaque additive.

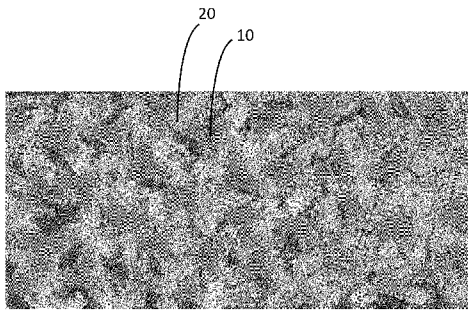

Fig. 1a

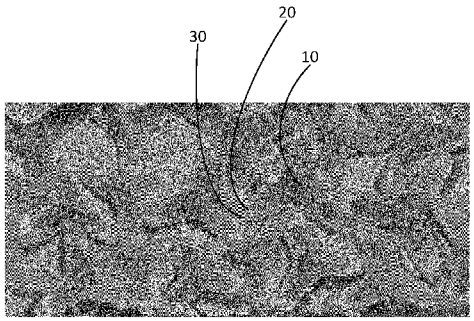

Fig. 1b

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FILAMENT OF RECYCLED POLYPROPYLENE FOR PILE YARN

Technical field

The present invention relates to a filament of a recycled polymer like polypropylene. Such filaments may be used in yarns for carpets, e.g. carpets comprising a backing and pile comprising tufts of pile yarn extending from the backing.

Background

For long, carpets and rugs have been used as textile floor coverings to provide comfort, durability, safety, and decoration. The terms carpets and rugs are used interchangeably in the art. They may be used to cover the entire floor in a room and fastened thereto. Sometimes, the term carpet is used to denote such a floor covering. The term carpet may however also be used to denote a textile floor covering not fastened and typically not covering the entire floor, in the same manner as the term rug is used.

Various yarns are used in producing carpets and rugs. Synthetic as well as natural fibers are used in such yarns. Synthetic fibers used in yarns for carpets and rugs include *inter alia* polyethyleneterephthalate (PET) fibers and polypropylene (PP) fibers.

Whereas use of re-cycled PET, e.g. from PET-bottles, has become common, re-cycling of PP has turned more challenging. Re-cycled polyethyleneterephthalate is typically transparent and not strongly discolored and may thus be colored in principle as desired by adding pigment. However, from a cost perspective PET is a more expensive material than PP. This also applies for other polyesters like polylactic acid (PLA). Further, the lower density of PP compared to PET, implies that more PET is needed to get the same yarn specification as with for PP. One of the most commonly used material in carpets is thus PP. Use of re-cycled PP would thus be highly desirable in order to provide more sustainable yarns at a low cost.

However, standard re-cycled PP is typically very dark, nearly black. Though there are qualities of re-cycled PP available not being that dark, these are typically more expensive making them less attractive from an economical perspective. Further, processes for purifying (i.e. discoloring) re-cycled PP are known in the art. As purification will add costs, it is less attractive from an economical perspective. The dark color of re-cycled PP hampers its use in providing yarns for textile applications, such as carpets and rugs. By adding pigments to re-cycled PP, the color may be slightly affected. However, the initial dark color still significantly limits the available colors.

Especially, lighter colors may in principle not be obtained. It would this be of interest to provide for replacing virgin PP with re-cycled PP in further applications.

DE202008016836U1 discloses non-woven carpet backing comprising bi-component binder fibers with a core/sheath structure. The core polymer is PET, whereas the sheath polymer is polyamide 6. By coloring the PET core polymer, the use of core polymers is no longer limited to raw materials with a constant coloration. Contrary to re-cycled PET, a dark constant color is however already at hand for re-cycled PP. Further, in carpet backing a dark material is typically acceptable.

In order to facilitate recycling of PP in filaments for yarns for e.g. carpets, it would be desired to provide for use of dark, recycled PP in filaments of various colored, such that flexibility is provided.

Summary

Accordingly, there is according to a first aspect provided a filament for a pile yarn. The filament is a multi-component filament comprising a core and at least a first sheath. The first sheath at least partly encloses the core. The core comprises recycled polypropylene and the first sheath comprises polypropylene. Further, the first sheath comprises a particulate, opaque additive. By coating the core of recycled polypropylene being dark (the dark color further varying between different batches) with a sheath comprising a particulate, opaque additive, the color of the core may be masked. Further, the at least a first sheath may, apart from the particulate, opaque additive, comprise a pigment to provide a colored filament. Thus, there is provided for use of dark, recycled polypropylene in filaments of various color.

The particulate, opaque additive is added to mask the color of the underlying core. It is thus preferred if the particulate additive is opaque. Further, the particulate, opaque additive is preferable white, or at least bright, to provide for flexibility in terms of color of the filament. The particulate, opaque additive may be an inorganic additive, such as titanium dioxide or calcium carbonate. According to an embodiment, the particulate, opaque additive is titanium dioxide. The content of the particulate, opaque additive may vary. On the one hand, a high content may improve the masking effect and provide a brighter filament, on the other, a too high content may negatively affect the mechanical properties of the filament, as well as the bonding between the filament and the core. The first sheath may typically comprise 5 to 40 wt.% of the particulate, opaque additive. Thus, it may comprise 5 to 30 wt.% or 10 to 20 wt.% of the particulate, opaque

additive. According to some embodiments, e.g. wherein a lighter color is desired, the first sheath may comprise at least 10 wt.% of the particulate, opaque additive.

As the first sheath is to mask the core, it may constitute 5 to 30 wt.% of the filament. According to some embodiments, it constitutes 10 to 25 wt.% of the filament. The more it constitutes, the better masking effect. However, as one objective is to provide for use of recycled polypropylene, it is preferred if the first sheath is a minor component, i.e. constitutes less than 50 wt.% of the filament. Further, the thickness of the first sheath may vary over its circumference; especially if the cross-section of filament is multi-lobal. In order to mask the core, the first sheath may be at least 0.2 µm thick, such as at least 1.0 µm thick. According to an embodiment, the first sheath is 1.0 to 10.0 µm thick, such as 1.0 to 4.0 µm thick.

Typically, the first sheath encloses the core entirely. However, in some embodiments it may be of interest to cover the circumference of the core only partly, thereby providing a filament with a mélange effect (also referred to as heathered effect in the art). The first sheath may thus enclose at least 80%, such as at least 90% or 95%, of the circumference of the core. Further, the first sheath may enclose 80 to 99%, such as 90% or 97%, of the circumference of the core.

In addition to the particulate, opaque additive (e.g. titanium dioxide), the first sheath may comprises a pigment, apart from the particulate, opaque additive. This pigment is typically not white. By adding a pigment, filaments of different colors may be provided. The particulate, opaque additive is typically white. By applying a first sheath to the core, whereby providing a multi-component filament, the particulate, opaque additive and the optional pigment may be localized to the surface of the filament. This implies that less additive has to be used in order to affect the color of the filament. Actually, a corresponding color as for the present multi-component filament is difficult to provide in recycled polypropylene mono-component filament, as a too high amount of the additives may affect the mechanical properties negatively.

However, according to some embodiments, the core may comprises an inorganic particulate, opaque additive, such as titanium dioxide or calcium carbonate. The core may comprise up to 5 wt.% of the inorganic particulate, opaque additive. A too high content of an inorganic particulate, opaque additive may, as already described, affect the mechanical properties of the filament negatively. Further, in order to compensate for a slight color variation between different batches and to provide a uniformly colored core, the core may comprise a dark pigment, such as carbon black.

The first sheath comprises polypropylene. This polypropylene may be virgin polypropylene. Virgin polypropylene does not suffer from being discolored. Further, the polypropylene in the first sheath may be recycled polypropylene. If to use recycled polypropylene in the first sheath, it is preferred if the recycled polypropylene in the first sheath is lighter in its color than the recycled polypropylene in the core. At least for some applications, e.g. in dark filaments, recycled polypropylene could be used in the first sheath. The discoloration of recycled polypropylene varies and lighter qualities are available, tough being a bit more expensive. Use of recycled polypropylene in filaments for carpets may thus be provided for either by using a first sheath comprising virgin polypropylene, or by using a first sheath comprising recycled polypropylene being lighter in its color than the recycled polypropylene in the core.

The present multi-component filament allows for use of darkly colored, recycled polypropylene. It is desired to use as much recycled material as possible in the filament. The core may constitutes at least 40 wt.% of the filament. According to an embodiment, the core constitutes 50 to 85 wt.% of the filament.

According to an embodiment, the multi-component filament further comprises a second sheath at least partly enclosing the first sheath. The second sheath comprises a polymer. By means of multi-component filament with a first and a second sheath, the color of the filament may even further be varied and adjusted. Further, the use of first sheath, masking the color of the core, and a second sheath, coloring the filaments, facilitates the provision of filaments with lighter colors. Further, concentrating pigments to an outermost layer implies the less pigment is required to provide the same color. According to an embodiment, the first sheath comprises a first pigment and the second sheath comprises a second pigment, distinct from the first pigment. By having a first pigment in the first sheath and a second pigment, distinct from the first pigment, in the second sheath, the color of the filament may be varied and adjusted. The apparent color of the filament may not be the same if both pigments are present in the same sheath. Further, the color may be different depending on which pigment is present in the outer sheath.

The polymer in the second sheath may be polypropylene. The polypropylene in the second sheath is typically virgin polypropylene. However, in some alternative embodiments, the polypropylene in the second sheath the second sheath may be, or at least comprise, recycled polypropylene. Similar to the first sheath, it is preferred if recycled polypropylene to be used in the second sheath is lighter in its color than the recycled polypropylene in the core.

According to an embodiment, the second sheath comprises polypropylene. However, while the polymer in the second sheath typically is polypropylene, it may also be another type of polymer, like polyester, such as semi-aromatic polyester (e.g. polyethylene terephthalate) or aliphatic polyamide (e.g. polyamide 6 or polyamide 66). According to an embodiment, the second sheath comprises a polyester, such as a semi-aromatic polyester (e.g. polyethylene terephthalate) and/or an aliphatic polyamide (e.g. polyamide 6 or polyamide 66). An outer sheath comprising a polyester, such as a semi-aromatic polyester (e.g. polyethylene terephthalate), and/or an aliphatic polyamide (e.g. polyamide 6 or polyamide 66) may provide the multi-component filament with improved moisture management.

Typically, the second sheath comprises a pigment. The pigment is typically not white, unless a whitish fiber is desired. The second sheath may comprises 1 to 20 wt.% of the pigment. Further, the second sheath may optionally, or alternatively, comprise a particulate, opaque additive. The particulate, opaque additive typically is white and may thus serve as white pigment as well. According to an embodiment, the second sheath comprises a particulate, opaque additive, such as titanium dioxide, and a pigment in addition to the particulate, opaque additive. The particulate, opaque additive may be an inorganic particulate, opaque additive, such as titanium dioxide or calcium carbonate. According to an embodiment, the particulate, opaque additive is titanium dioxide. The second sheath may comprise 5 to 40 wt.%, such as such as 5 to 30 wt.% or 10 to 20 wt.%, of the particulate, opaque additive. According to some embodiments, wherein a lighter color is desired, the second sheath may comprise at least 10 wt.% of the particulate, opaque additive.

As the second sheath is to color the filament, it may constitute 5 to 30 wt.% of the filament. According to some embodiments, it constitutes 10 to 25 wt.% of the filament. The more it constitutes, the stronger coloring effect. However, as one objective is to provide for use of recycled polypropylene, it is preferred if the second sheath is a minor component, i.e. constitutes less than 50 wt.% of the filament. Further, the thickness of the second sheath may vary over its circumference; especially if the cross-section of filament is multilobal. In order to color the filament, the second sheath may be at least 0.2 µm thick, such as at least 1.0 µm thick. According to an embodiment, the second sheath is 1.0 to 10.0 µm thick, such as 1.0 to 4.0 µm thick.

Furthermore, both the first and the second sheath affects the color of the resulting filament. In some embodiments, the first sheath constitutes larger proportion of the filament than the second sheath. According to such an embodiment, the first

sheath may constitute 10 to 30 wt.% of the filament, whereas the second sheath may constitute 5 to 20 wt.% of the filament. Provided that the first sheath sufficiently masks the core, the second sheath may be somewhat thinner, still providing the desired color.

Typically, the second sheath encloses the first sheath entirely. However, in some embodiments it may be of interest to cover the circumference of the first sheath only partly, thereby providing a filament with a mélange effect . The second sheath may thus enclose at least 80%, such as at least 90% or 95%, of the circumference of the first sheath. Further, the second sheath may enclose 80 to 99%, such as 90% or 97%, of the circumference of the first sheath.

Further, though the polymer in the core typically is recycled polypropylene, the concept of using a first and a second sheath may be applied also in providing filaments of various colors, wherein the core comprise other types of recycled polymers than polypropylene, like a polyester, such as a semi-aromatic polyester (e.g. polyethylene terephthalate) or an aliphatic polyamide (e.g. polyamide 6 or polyamide 66). According to a second aspect, there is thus provided a multi-component filament for a pile yarn. The multi-component filament comprises a core, at a first sheath, at least partly enclosing the core, and a second sheath, at least partly enclosing the first sheath. The core comprises a polymer, typically a recycled polymer. This polymer may be a polyolefin (e.g. polypropylene), a polyester, such as a semi-aromatic polyester (e.g. polyethylene terephthalate), or an aliphatic polyamide (e.g. polyamide 6 or polyamide 66). Similarly, the first sheath comprise a polymer. The first sheath may thus comprise a polyolefin (e.g. polypropylene), an aliphatic polyamide (e.g. polyamide 6 or polyamide 66), or a polyester, such as semi-aromatic polyester (e.g. polyethylene terephthalate). As already outlined herein above, the polymer used in the first sheath is typically a virgin polymer. It may however also be a recycled polymer. If to use a recycled polymer in the first sheath, it is preferred if such recycled polymer is lighter in its color than the recycled polymer in the core. Further, also the second sheath comprises a polymer. The second sheath may thus comprise a polyolefin (e.g. polypropylene), an aliphatic polyamide (e.g. polyamide 6 or polyamide 66), or a polyester, such as semi-aromatic polyester (e.g. polyethylene terephthalate). As already outlined herein above, the polymer used in the second sheath is typically a virgin polymer. It may however also be a recycled polymer. If to use a recycled polymer in the second sheath, it is preferred if such recycled polymer is lighter in its color than the recycled polymer in the core. Furthermore, similar to what already have been described, the first sheath comprises a first particulate, opaque additive. The first particulate, opaque additive may be an

inorganic additive, such as titanium dioxide or calcium carbonate. Preferably, the first particulate, opaque additive is titanium dioxide. In a corresponding manner, the second sheath does optionally comprise a pigment and/or a second particulate, opaque additive. The second particulate, opaque additive, if present, may be an inorganic additive, such as titanium dioxide or calcium carbonate. Preferably, the second particulate, opaque additive is titanium dioxide.

By means of multi-component filament with a first and a second sheath, the color of the filament may even further be varied and adjusted. Further, the use of first sheath, masking the color of the core, and a second sheath, coloring the filaments, facilitates the provision of filaments with lighter colors. Further, concentrating pigments to an outermost layer implies the less pigment is required to provide the same color. According to an embodiment, the first sheath comprises a first pigment and the second sheath comprises a second pigment, distinct from the first pigment. By having a first pigment in the first sheath and a second pigment, distinct from the first pigment, in the second sheath, the color of the filament may be varied and adjusted. The apparent color of the filament may not be the same if both pigments are comprised in the same sheath. Further, the color may be different, depending on which pigment is present in the outer sheath.

Preferred embodiments of the first and second aspect of the invention are closely related to each other. Thus, the first sheath may comprises 5 to 40 wt.%, such as 5 to 30 wt.% or 10 to 20 wt.%, of the particulate, opaque additive. Further, the second sheath may comprise 1 to 20 wt.% of the pigment and/or 5 to 30 wt.%, such as 5 to 30 wt.% or 10 to 20 wt.%, of the particulate, opaque additive. Furthermore, the core may constitutes at least 40 wt.%, such as 50 to 85 wt.%, of the filament. The first sheath may constitute 5 to 30 wt.%, such as 10 to 25 wt.%, of the filament. The second sheath may constitute 5 to 30 wt.%, such as 10 to 25 wt.%, of the filament.

In a corresponding manner as described for the first aspect, the thickness of the first sheath may in embodiments of according to the second aspect, vary over its circumference; especially if the cross-section of filament is multilobal. In order to mask the core, the first sheath may be at least 0.2 μm thick, such as at least 1.0 μm thick. According to an embodiment, the first sheath is 1.0 to 10.0 μm thick, such as 1.0 to 4.0 μm thick. Further, the first sheath typically encloses the core entirely. However, in some embodiments it may be of interest to cover the circumference of the core only partly, thereby providing a filament with a mélange effect. The first sheath may thus enclose at least 80%, such as at least 90% or 95%, of the circumference of the core. Further, the

first sheath may enclose 80 to 99%, such as 90% or 97%, of the circumference of the core. Similarly, the second sheath may be at least 0.2 µm thick, such as at least 1.0 µm thick. According to an embodiment, the second sheath is 1.0 to 10.0 µm thick, such as 1.0 to 4.0 µm thick. Furthermore, the second sheath typically encloses the first sheath entirely. However, in some embodiments it may be of interest to cover only the circumference of the first sheath partly, thereby providing a filament with a mélange effect. The second sheath may thus enclose at least 80%, such as at least 90% or 95%, of the circumference of the first sheath. Further, the second sheath may enclose 80 to 99%, such as 90% or 97%, of the circumference of the first sheath.

Turning to preferred features equally applicable to both aspects of the invention as outlined herein above, it is to be noted that the cross-section of the multi-component filament may have at least two lobes. The cross-section of the multi-component filament may thus be bi-lobal, tri-lobal, or quad-lobal. The cross-section of the filament does not only directly affect mechanical properties. Especially when used in carpets, also other properties like the hand-feel and touch are affected and typically improved, as described in WO 2022/005383. For a filament with a bi-lobal cross-section, it is preferred if the waist is concave. For a filament with tri-lobal or the quad-lobal cross-section, it is preferred if the sides are concave. The present is not limited to a given size or diameter. The liner mass density of the filament may be in the range 1 dtex to 20 dtex.

Further, additional additives may be present in the first sheath and/or the second sheath. According to one embodiment, a reflective additive, such as glass beads, glitter, or crystal, is present in the first sheath and/or the second sheath. The reflective additive may be a retro-reflective additive, such as glass beads. Further, additives making the filament, or a pile yarn comprising the filament, changing color with different light sources may be added. According to an embodiment, the additive is a photochromic material. Photochromic materials change color when exposed to e.g. UV light. The photochromic material used is typically reversible. Some common examples of photochromic materials include silver halides, spirooxazines and naphthopyrans. In some embodiments, a reflective additive or a photochromic material is used instead of a pigment in the second sheath.

According to a third aspect, there is provided a multi-component filament for a pile yarn. The multi-component filament comprises a core, at a first sheath, at least partly enclosing the core, and a second sheath, at least partly enclosing the first sheath. The core comprises a polymer, typically a recycled polymer. This polymer may be a

polyolefin (e.g. polypropylene), polyester, such as a semi-aromatic polyester (e.g. polyethylene terephthalate), or an aliphatic polyamide (e.g. polyamide 6 or polyamide 66). Similarly, the first sheath comprise a polymer. The first sheath may thus comprise a polyolefin (e.g. polypropylene), an aliphatic polyamide (e.g. polyamide 6 or polyamide 66), or a polyester, such as a semi-aromatic polyester (e.g. polyethylene terephthalate). As already outlined herein above, the polymer used in the first sheath is typically a virgin polymer. It may however also be a recycled polymer. If to use a recycled polymer in the first sheath, it is preferred if such recycled polymer is lighter in its color than the polymer in the core. Further, also the second sheath comprises a polymer. The second sheath may thus comprise a polyolefin (e.g. polypropylene), an aliphatic polyamide (e.g. polyamide 6 or polyamide 66), or a polyester, such as a semi-aromatic polyester (e.g. polyethylene terephthalate). As already outlined herein above, the polymer used in the second sheath is typically a virgin polymer. It may however also be a recycled polymer. If to use a recycled polymer in the second sheath, it is preferred if such recycled polymer is lighter in its color than the polymer in the core. Further, the first sheath optionally comprises a first additive. The second sheath comprises a second additive. The second additive is distinct from the first additive if present. By having distinct additives in separate sheaths, the properties of the filament may be improved and tuned. Further, the presence of the first sheath will separate the additive in the second sheath from the core. It will be appreciated that each sheath may comprise several additives, and it is sufficient if one of these additives is distinct between the first and second sheaths.

Preferred embodiments of the second and third aspect of the invention are closely related to each other. Thus, the core of the filament may constitute at least 40 wt.%, such as 50 to 85 wt.%, of the filament. Further, the first sheath may constitute 5 to 30 wt.%, such as 10 to 25 wt.%, of the filament. Furthermore, the second sheath may constitute 5 to 30 wt.%, such as 10 to 25 wt.%, of the filament. The first sheath may be at least 0.2 μm thick, such as at least 1.0 μm thick. The first sheath may enclose at least 80%, such as at least 90% or 95%, of the circumference of the core. According to an embodiment, the first sheath encloses the core entirely. The second sheath may be at least 0.2 μm thick, such as at least 1.0 μm thick. The second sheath may enclose at least 80%, such as at least 90% or 95%, of the circumference of the first sheath. According to an embodiment, the second sheath encloses the first sheath entirely.

Various polymers may as already outlined, be used in the filament. Further, various combinations of polymers be used. According to an embodiment, the polymer

in the first sheath is distinct from the polymer in the second sheath. According to another embodiment, the polymer in the first sheath is the same type of polymer as the polymer in the second sheath. Further, the polymer in the core may according to an embodiment be distinct from the polymer in the first sheath. Alternatively, the polymer in the core may be the same type of polymer as the polymer in the first sheath.

The cross-section of the multi-component filament has at least two lobes. According to an embodiment, its cross-section is bi-lobal, tri-lobal or quad-lobal. According to an embodiment, the waist of a bi-lobal cross-section is concave and the sides of a tri-lobal and/or a quad-lobal cross-section is concave.

The liner mass density of the filament may be 1 dtex to 20 dtex.

According to a fourth aspect, there is provided a yarn, such as a pile yarn. The yarn comprises at least two filaments, but typically further filaments are present, of the type described herein above. Further, the yarn may be drawn and texturized to form a bulked continuous fiber (BCF) yarn. Thus, the yarn may be bulked continuous fiber (BCF) yarn. Manufacture of bi-component continuous filaments having a sheath-core arrangement for use in e.g. bulk continuous filament (BCF) fibers and floor coverings, such as mats, rugs, and carpets is known in the art (see for example US2018282908A1).

According to a fifth aspect, there is provided a staple fiber. The staple fiber is obtainable by cutting the filament of the type described herein above into staple fibers. The staple fibers may be 20 to 100 mm long, such as 30 to 70 mm long.

According to a sixth aspect, there is provided a carpet or a rug. The carpet or the rug comprises the yarn described herein above, or the staple fibers described herein above.

According to a seventh aspect, there is provided a method of producing a filament according to the first, or the second, aspect of the invention as disclosed herein above. The method comprises the steps of:

- extruding a first melt comprising a recycled polymer such as polypropylene, to form a core, a second melt comprising a polymer, such as polypropylene, and a particulate, opaque additive to form a sheath at least partly enclosing the core, and optionally a third melt comprising a polymer, preferably polypropylene, to form a second sheath at least partly enclosing the first sheath;
- drawing and solidifying the filament; and
- optionally texturing and/or stretching the filaments.

Further aspects of such an embodiment is disclosed *inter alia* in WO 2022/005383.

Although the present invention has been described above with reference to specific embodiments, it is not intended to be limited to the specific form set forth herein. Rather, the invention is limited only by the accompanying claims and other embodiments than the specific embodiments described above are equally possible within the scope of these appended claims.

In the claims, the term "comprises/comprising" does not exclude the presence of other elements or steps. Additionally, although individual features may be included in different claims, these may possibly advantageously be combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous.

In addition, singular references do not exclude a plurality. The terms "a", "an", “first”, “second” etc. do not preclude a plurality.

Brief description of the drawings

These and other aspects, features and advantages of which the invention is capable of will be apparent and elucidated from the following description of embodiments of the present invention, reference being made to the accompanying drawings, in which:

Fig. 1a shows a cross-section of filaments with a first sheath according to an embodiment;

Fig. 1b shows a cross-section of filaments with a first sheath and a second sheath according to an embodiment;

Detailed description

In **Fig. 1a**, a number of cross-section of filaments according to an embodiment is shown. The filament is a bi-component filament with a first sheath 20 enclosing a core 10. The filament’s cross-section is tri-lobal. As can be seen, the thickness if the first sheath 20 varies slightly over the circumference of the filament.

In **Fig. 1b**, a number of cross-section of filaments according to an embodiment is shown. The filament is a tri-component filament with a first sheath 20, enclosing a core 10, and a second sheath 30, enclosing the first sheath 20. The filament’s cross-section is tri-lobal. As can be seen, the thickness of the first sheath 20 and the second sheath 30, respectively, varies slightly over the circumference of the filament.

Experimental

Filament spinning and yarn drawing

The present sheath-core fibers may be spun using conventional fiber-forming equipment. Thus, for example, separate melt flows of the virgin sheath polypropylene and re-cycled core polypropylene may be fed to a conventional sheath-core spinneret pack (examples are given *inter alia* in US 5,162,074, US 5,125,818, US 5,344,297 and 5,445,884) where the melt flows are combined to form extruded multi-lobal (e.g., tri-, tetra-, penta- or hexalobal) filaments having sheath and core structures. In embodiments including two sheaths, an additional melt flow is fed to the spinneret pack.

After the extrusion, the extruded filaments are quenched, for example with air, in order to solidify the filaments. The filaments may then be treated with a finish comprising a lubricating oil or mixture of oils and antistatic agents. The thus formed filaments are then combined to form a yarn bundle.

In a subsequent step, the yarn may be drawn and texturized to form a bulked continuous fiber (BCF) yarn suitable for e.g. tufting into carpets. Further, the spinning and the drawing may be combined in a single process. A one-step method of making BCF is generally known in the art as spin-draw-texturing (SDT).

Example 1

A first flat yarn (cf. **Fig 1a**) of core sheath-core filaments with recycled polypropylene in the core 10 were provided with the following specification:

Weight ratio core/sheath: 60/40

Polymer in the core 10: recycled polypropylene from A.D. Compound S.p.a. (MFI at 230°C/2.16 kg according to ISO 1133: 26.4 g/10 min; density at 23°C 0.964 g/cm^3)

Additives in the core 10: TiO_2 (5 wt.%) and carbon black (3 wt.%)

Polymer in the sheath 20: virgin polypropylene (Metocene MF650Y) from LyondellBasell (MFI at 230°C/2.16 kg according to ISO 1133: 18 g/10 min)

Additives in the sheath 20: TiO_2 (35 wt.%) and red pigment (2 wt.%)

Linear density filament: 12 denier per filament (dpf)

Linear density yarn: 1700 dtex

The yarn was reddish brown had a tenacity of 2.16 and an elongation of 106%

Example 2

A second flat yarn (cf. **Fig 1b**) of sheath-sheath-core filaments with recycled polypropylene in the core 10 were provided with the following specification:

Weight ratio core/sheath/sheath: 60/30/10

Polymer in the core 10: recycled polypropylene MFI at 230°C/2.16 kg according to ISO 1133: 26.4 g/10 min; density at 23°C 0.964 g/cm^3)

Additives in the core 10: carbon black (3 wt.%)

Polymer in the first sheath 20: virgin polypropylene (Metocene MF650Y) from LyondellBasell (MFI at 230°C/2.16 kg according to ISO 1133: 18 g/10 min)

Additives in the first sheath 20: TiO_2 (15 wt.%)

Polymer in the second sheath 30: virgin polypropylene (Metocene MF650Y) from LyondellBasell (MFI at 230°C/2.16 kg according to ISO 1133: 18 g/10 min)

Additives in the second sheath 30: TiO_2 (10 wt. %) and yellow pigment (2 wt.%)

Linear density filament: 12 denier per filament (dpf)

Linear density yarn: 1800 dtex

The yarn was greenish and had a tenacity of 2.08 and an elongation of 98%

CLAIMS

1. A filament for a pile yarn, wherein the filament is a multi-component filament comprising a core (10) and at least a first sheath (20) at least partly enclosing the core (10), said core (10) comprising recycled polypropylene, wherein said first sheath (20) comprises polypropylene and a particulate, opaque additive.

2. The filament according to claim 1, wherein the particulate, opaque additive is an inorganic additive, such as titanium dioxide or calcium carbonate; preferably the particulate, opaque additive being titanium dioxide.

3. The filament according to claim 1 or 2, wherein the first sheath (20) comprises 5 to 40 wt.%, such as 5 to 30 wt.% or 10 to 20 wt.%, of the particulate, opaque additive.

4. The filament according to any one of claims 1 to 3, wherein

the first sheath (20), in addition to the particulate, opaque additive, further comprises a pigment; and/or

the core (10) comprises up to 5 wt.% of a particulate, opaque additive, preferably an inorganic particulate, opaque additive, such as titanium dioxide or calcium carbonate, and/or the core (10) comprises a pigment, such as carbon black.

5. The filament according to any one of claims 1 to 4, wherein the core (10) constitutes at least 40 wt.%, such as 50 to 85 wt.%, of the filament.

6. The filament according to any one of claims 1 to 5, wherein the multi-component filament further comprises a second sheath (30) at least partly enclosing the first sheath (20), said second sheath (30) comprising a polymer, preferably said polymer being polypropylene.

7. The filament according to claim 6, wherein the second sheath (30) comprises a pigment and/or a particulate, opaque additive, preferably an inorganic particulate, opaque additive, such as titanium dioxide or calcium carbonate.

8. The filament according to claim 7, wherein the second sheath (30) comprises 1 to 20 wt.% of the pigment and/or 5 to 40 wt.%, such as such as 5 to 30 wt.% or 10 to 20 wt.%, of the particulate, opaque additive.

9. The filament according to any one of claims 1 to 8, wherein:

- the first sheath (20) constitutes 5 to 30 wt.%, such as 10 to 25 wt.%, of the filament; and/or
- the first sheath (20) is at least 0.2 μm thick, such as at least 1.0 μm thick; and/or
- the first sheath (20) encloses at least 80%, such as at least 90% or 95%, of the circumference of the core (10); preferably the first sheath (20) encloses the core (10) entirely; and/or
- the second sheath (30), if present, constitutes 5 to 30 wt.%, such as 10 to 25 wt.%, of the filament; and/or
- the second sheath (30), if present, is at least 0.2 μm thick, such as at least 1.0 μm thick; and/or
- the second sheath (30), if present, encloses at least 80%, such as at least 90% or 95%, of the circumference of the first sheath (20); preferably the second sheath (30) encloses the first sheath (20) entirely.

10. The filament according to any one of claims 1 to 9, wherein the first sheath (20) comprises virgin polypropylene, or wherein the first sheath (20) comprises recycled polypropylene; preferably the recycled polypropylene in the first sheath (20) being lighter in its color than the recycled polypropylene in the core (10); and/or wherein the second sheath (30), if present, comprises virgin polypropylene, or wherein the second sheath (30) comprises recycled polypropylene; preferably the recycled polypropylene in the second sheath (30) being lighter in its color than the recycled polypropylene in the core (10).

11. A filament for a pile yarn, wherein the filament is a multi-component filament, comprising a core (10), comprising a polymer, at least a first sheath (20) at least partly enclosing the core (10), and a second sheath (30) at least partly enclosing the first sheath (20), wherein said first sheath (20) comprises a polymer and a first particulate, opaque additive, and wherein said second sheath (30) optionally comprises a polymer, a pigment, and/or a second particulate, opaque additive.

12. The filament according to claim 11, wherein the first particulate, opaque additive is an inorganic additive, such as titanium dioxide or calcium carbonate; preferably the additive being titanium dioxide; and

wherein the second particulate, opaque additive, if present, is an inorganic additive, such as titanium dioxide or calcium carbonate; preferably the additive being titanium dioxide.

13. The filament according to claim 11 or 12, wherein:

- the first sheath (20) comprises 5 to 40 wt.%, such as 5 to 30 wt.% or 10 to 20 wt.%, of the particulate, opaque additive; and/or
- the second sheath (30) comprises 1 to 20 wt.% of the pigment, and/or 5 to 30 wt.%, such as 5 to 30 wt.% or 10 to 20 wt.%, of the particulate, opaque additive.

14. The filament according to any one of claims 11 to 13, wherein:

- the core (10) constitutes at least 40 wt.%, such as 50 to 85 wt.%, of the filament; and/or
- the first sheath (20) constitutes 5 to 30 wt.%, such as 10 to 25 wt.%, of the filament; and/or
- the second sheath (30) constitutes 5 to 30 wt.%, such as 10 to 25 wt.%, of the filament.

15. The filament according to any one of claims 11 to 14, wherein:

- the first sheath (20) is at least 0.2 µm thick, such as at least 1.0 µm thick; and/or
- the first sheath (20) encloses at least 80%, such as at least 90% or 95%, of the circumference of the core (10); preferably the first sheath (20) encloses the core (10) entirely; and/or
- the second sheath (30) is at least 0.2 µm thick, such as at least 1.0 µm thick; and/or
- the second sheath (30) encloses at least 80%, such as at least 90% or 95%, of the circumference of the first sheath (20); preferably the second sheath (30) encloses the first sheath (20) entirely.

16. The filament according to any one of claims 11 to 15, wherein:

- the polymer in the core (10) is recycled polyolefin, recycled aliphatic polyamide, or recycled polyester, such as recycled semi-aromatic polyester; preferably the polymer in the core (10) being recycled polypropylene; and/or

- the polymer in the first sheath (20) is polyolefin, aliphatic polyamide, or polyester, such as semi-aromatic polyester; preferably the polymer in the first sheath (20) being polypropylene; and/or

- the polymer in the second sheath (30) is polyolefin, aliphatic polyamide, or polyester, such as semi-aromatic polyester; preferably the polymer in the second sheath (30) being polypropylene.

17. The filament according to any one of claims 1 to 16, wherein the cross-section of the multi-component filament has at least two lobes, preferably the cross-section being bi-lobal, tri-lobal or quad-lobal; more preferably the waist of the bi-lobal cross-section being concave and the sides of the tri-lobal and/or the quad-lobal cross-section being concave.

18. The filament to any one of claims 1 to 16, wherein the liner mass density of the filament is 1 dtex to 20 dtex.

19. A filament for a pile yarn, wherein the filament is a multi-component filament, comprising a core (10), the core (10) comprising a polymer, at least a first sheath (20) at least partly enclosing the core (10), and a second sheath (30) at least partly enclosing the first sheath (20), wherein said first sheath (20) comprises a polymer and optionally a first additive, and wherein said second sheath (30) comprises a polymer and a second additive, said second additive being distinct from the first additive.

20. The filament according to claim 19, wherein the polymer in the core (10) is a recycled polymer.

21. The filament according to any one of claims 19 to 20, wherein:

- the core (10) constitutes at least 40 wt.%, such as 50 to 85 wt.%, of the filament; and/or

- the first sheath (20) constitutes 5 to 30 wt.%, such as 10 to 25 wt.%, of the filament; and/or

- the second sheath (30) constitutes 5 to 30 wt.%, such as 10 to 25 wt.%, of the filament.

22. The filament according to any one of claims 19 to 21, wherein:

- the first sheath (20) is at least 0.2 μm thick, such as at least 1.0 μm thick; and/or

- the first sheath (20) encloses at least 80%, such as at least 90% or 95%, of the circumference of the core (10); preferably the first sheath (20) encloses the core (10) entirely; and/or

- the second sheath (30) is at least 0.2 μm thick, such as at least 1.0 μm thick; and/or

- the second sheath (30) encloses at least 80%, such as at least 90% or 95%, of the circumference of the first sheath (20); preferably the second sheath (30) encloses the first sheath (20) entirely.

23. The filament according to any one of claims 19 to 22, wherein:

- the polymer in the core (10) is recycled polyolefin, recycled aliphatic polyamide, or recycled polyester, such as a semi-aromatic polyester; preferably the polymer in the core (10) being recycled polypropylene; and/or

- the polymer in the first sheath (20) is polyolefin, aliphatic polyamide, or a polyester, such as a semi-aromatic polyester; and/or

- the polymer in the second sheath (30) is polyolefin, aliphatic polyamide, or a polyester, such as a semi-aromatic polyester.

24. The filament according to any one of claims 19 to 23, wherein the polymer in the first sheath (20) is distinct from the polymer in the second sheath (30).

25. The filament according to any one of claims 19 to 23, wherein the polymer in the first sheath (20) is the same type of polymer as the polymer in the second sheath (30).

26. The filament according to any one of claims 19 to 25, wherein the polymer in the core (10) is distinct from the polymer in the first sheath (20).

27. The filament according to any one of claims 19 to 25, wherein the polymer in the core (10) is the same type of polymer as the polymer in the first sheath (20).

28. The filament according to any one of claims 19 to 27, wherein the cross-section of the multi-component filament has at least two lobes, preferably the cross-section being bi-lobal, tri-lobal or quad-lobal; more preferably the waist of the bi-lobal cross-section being concave and the sides of the tri-lobal and/or the quad-lobal cross-section being concave.

29. The filament to any one of claims 19 to 28, wherein the liner mass density of the filament is 1 dtex to 20 dtex.

30. A yarn comprising at least two filaments according to any one of claims 1 to 29.

31. A staple fiber, wherein the staple fiber is obtainable by cutting the filament according to any one of claims 1 to 29 into staple fibers; preferably the staple fibers being 20 to 100 mm long, such as 30 to 70 mm long.

32. A carpet or a rug comprising the yarn according claim 30, or the staple fibers according to claim 31.

33. A method of producing a filament according to any one of claims 1 to 29, wherein the method comprises the steps of:

- extruding a first melt comprising recycled polypropylene to form a core (10), a second melt comprising polypropylene and optionally a particulate, opaque additive to form a sheath (20) at least partly enclosing the core (10), and optionally a third melt comprising a polymer, preferably polypropylene, to form a second sheath (30) at least partly enclosing the first sheath (20);
- drawing and solidifying the filament; and
- optionally texturing and/or stretching the filaments.

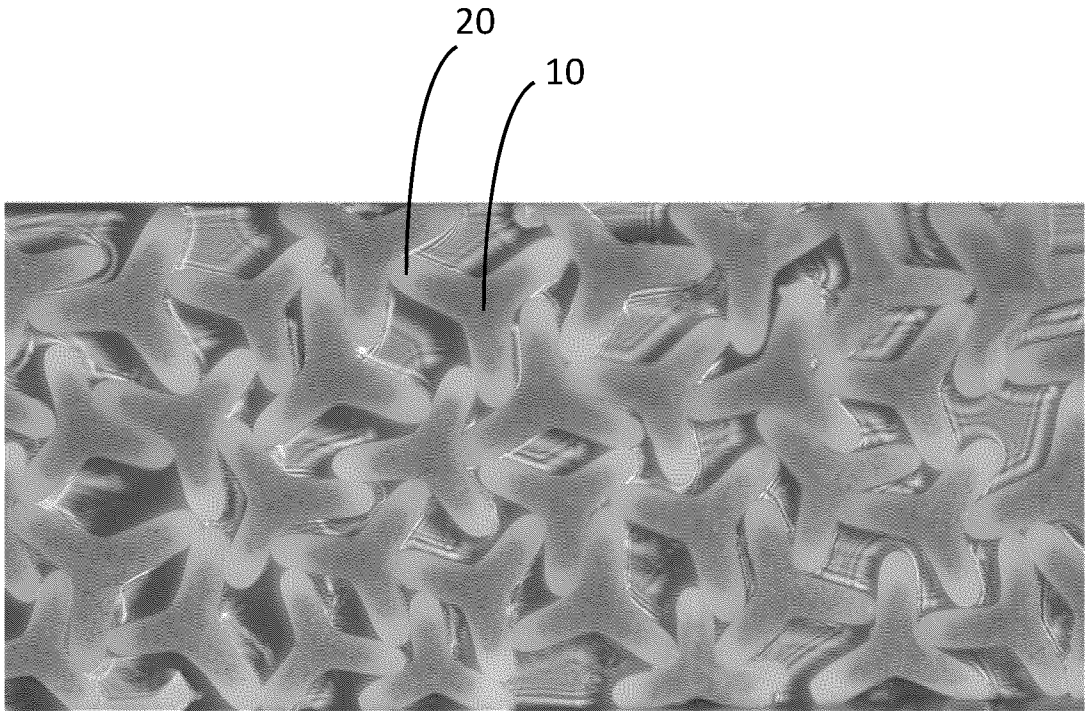

Fig. 1a

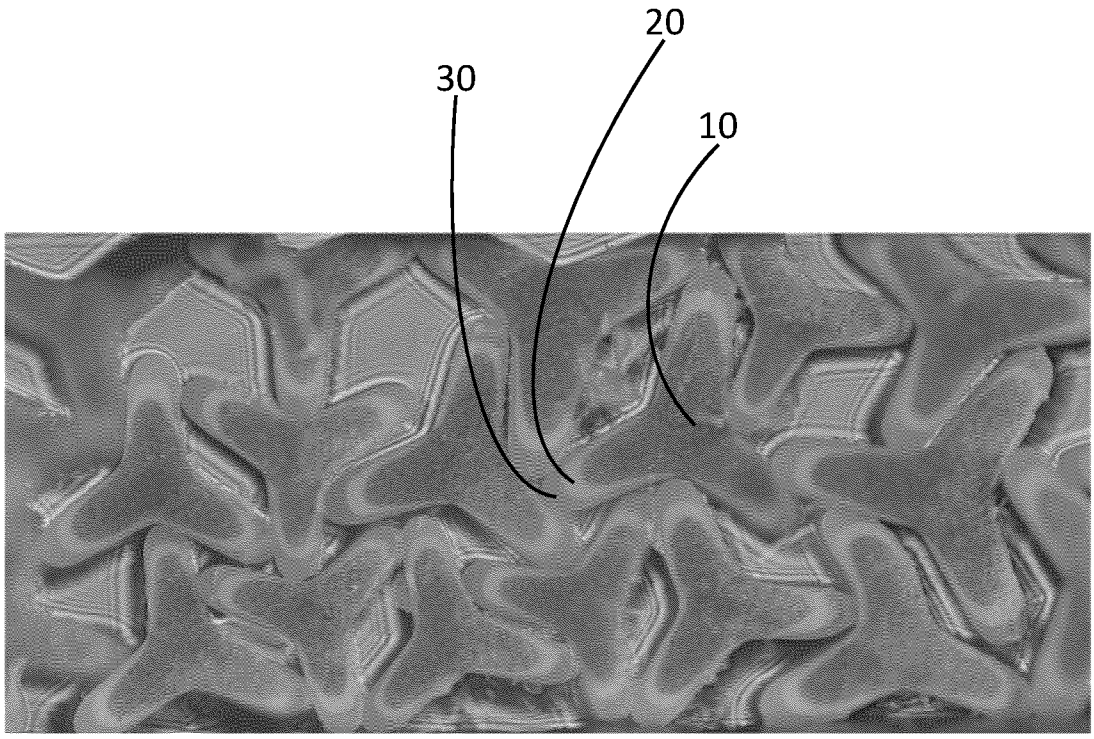

Fig. 1b

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/067693

A. CLASSIFICATION OF SUBJECT MATTER
INV. D01F6/06 D01F8/06 D06N7/00
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)
D01F D06Q D06N

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017/002116 A1 (LAYMAN JOHN MONCRIEF [US] ET AL) 5 January 2017 (2017-01-05)	1-29,31, 33
Y	paragraphs [0001], [0015], [0052], [0054], [0074], [0076], [0080], [0098], [0097], [0100], [0103], [0106], [0110]	1,30,32
Y	JP 2003 129329 A (MITSUBISHI RAYON CO) 8 May 2003 (2003-05-08) paragraphs [0005], [0015], [0016], [0028], [0036]; examples 1,5	1,30,32

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

☒ See patent family annex.

* Special categories of cited documents :

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"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	Date of mailing of the international search report
25 September 2023	04/10/2023

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2023/067693

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017002116 A1	05-01-2017	US 2017002116 A1	05-01-2017
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