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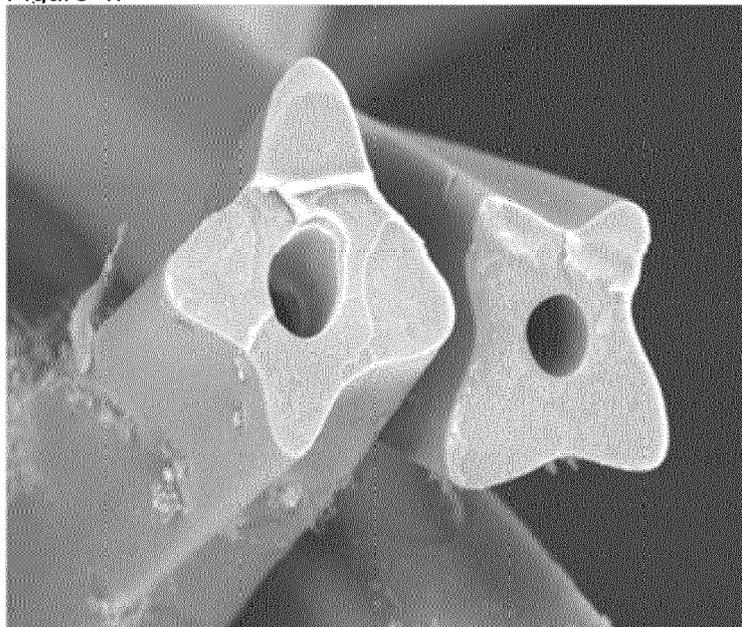
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(54) **SQUARE HOLLOW FIBER**

(57) The present invention relates to a polymeric fiber comprising at least one square hollow region, filters and carpets comprising the polymeric fiber, a nonwoven fabric comprising the polymeric fiber, the use of the poly-

meric fiber and a capillary spinneret orifice comprising a pattern of arranged holes designed to provide said polymeric fibers.

Figure 1:



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Description

BACKGROUND

[0001] The present invention relates to a polymeric fiber comprising at least one square hollow region, filters and carpets comprising the polymeric fiber, a nonwoven fabric comprising the polymeric fiber, the use of the polymeric fiber and a capillary spinneret orifice comprising a pattern of arranged holes designed to provide said polymeric fibers.

STATE OF THE ART

[0002] Polymeric fibers are obtained by various known spinning processes. Fibers from polymers that become flowable and pliable under heating, in particular thermoplastics, can be produced by melt spinning processes. Melt spinning is a specialized form of extrusion, wherein a polymeric material is melted in order to obtain a polymer melt which is then passed through a spinneret, i.e. a type of die used to form continuous filaments. In a usual embodiment, the spinneret comprises a metal plate with an arrangement (pattern) of small holes through which the polymer melt is passed into the air or a liquid for solidification and fiber formation. The design of the spinneret varies greatly. Conventional spinneret orifices are circular and produce fibers that are round in cross section. Capillary spinneret orifices enable extrusion of filaments with small diameters of one denier or less. The extruded molten filaments exiting the spinneret are cooled to obtain the final fibers which have the shape of the outlet openings of the spinneret plate. It is known to use spinneret orifices having shaped holes to obtain fibers of different shapes and with various characteristics.

[0003] Different shapes of fibers and multi-lobal fibers have been known for many years. The known fibers can be of a triangular cross section, so called trilobal fibers. The fibers can be of a square shape, they can be a star shape fiber with four, five, six or more fingers. Furthermore, fibers showing flat oval, T-shape, M-shape, S-shape, Y-shape, or H-shape cross sections are known.

[0004] The single fibers (filaments) can be spun to yarns, and a number of yarns can be plied together for producing threads.

[0005] One special aspect is the use of polymer fibers for the manufacture of carpets. Tufted carpets are multilayer, pile textiles. They are manufactured on special machines on which the pile yarn is joined but not tied, by means of needles, with a base layer, which in the case of carpets today consists almost exclusively of synthetic fibers. The anchoring of the pile yarn is accomplished by a subsequent coating of the reverse side of the base layer with natural or synthetic rubber or with polyvinyl chloride (PVC). The rubber coating moreover is joined to a so-called secondary backing, which as a rule consists of an elastomer foam or a woven or non-woven textile material.

[0006] Tufted products find many uses, for example, as carpets, runners, textile tiles, bedspreads, bath mats, etc. In their production, the base layer in particular is of considerable importance. The task of base layer is a safe anchoring of the pile yarn.

[0007] The term "tufting" refers to a technology for the production of three-dimensional textile sheets. It is the process most frequently employed worldwide for preparing carpets. Tufting works on the principle of a sewing machine. Needles insert the so-called pile yarn into a base material (woven or non-woven fabric), the so-called primary backing or support. The needles stitch through the base material; before the needles are running back again, the inserted pile yarn is held by loopers. This produces loops (pile knots) on the top side of the tufting fabric. In this way, a so-called loop-pile carpet is obtained. If the loops are cut open with a knife, a velour carpet (cut-pile carpet) is formed. Frequently, the knife is already attached to the looper, so that the holding and cutting of the pile is done in one operation. In order to hold the stitched pile yarn tight, a secondary backing or latex layer must be applied. This process is referred to as lamination or integration.

[0008] EP 1619283 describes a method for producing a tufted nonwoven fabric, wherein fibers, which are divergent from a round fiber cross section, are used for tuft backing.

[0009] EP 1878817 describes square fibers for airtightness fabrics. The disclosed fibers may be hollow or non-hollow fibers. Hollow square fibers are solely mentioned as one alternative. However, the shape and the dimension of the hollow region of the fibers are not disclosed.

[0010] WO 2018/113767 describes hollow polyester fibers, which have a cross-sectional hollowness ranging from 20.0% to 45.0%. The fiber itself and the hollow have a crimped shape, wherein the radius of curvature of the crimped shape being 10.0 mm-50.0 mm.

[0011] WO 2006/133036 and WO 2006/020109 describe mixtures of various shaped fibers to provide improvements in opacity, barrier properties, and mechanical properties. The variety of cross sections include solid round fibers, hollow round fibers, multi-lobal solid fibers, hollow multi-lobal fibers, square shaped fibers, crescent shaped fibers, and any combination thereof.

[0012] CN 203999944 describes a square hollow fiber. The square hollow fiber is formed by connecting two L-shape parts. The side lengths are from 0.04 to 1.00 mm, the width lengths are from 0.001 to 0.009 mm, the minimum distance of the L-shape holes is from 0.001 to 0.008 mm, the inner and outer radius of the arc formed by the L-shape is 0.001 to 0.009 mm, the angle is 90°. The present invention are distinct from CN 203999944 in the dimension of the square hollow, an outer diameter and the shape of the fiber.

[0013] CN 101748501 describes square hollow fiber and a production method thereof. The cross section of the fiber has a square hollow shape. The length ratio of the longest side to the shortest side is 1-2:1, the angle

is from 45 to 135 °, the hollowness of the fiber is from 12 to 25 %. The distinguishing feature is the ratio of the longest side to the shortest side, which is 5 : 1 to 6 : 1.

[0014] US 2003/039827 relates to a fiber having a square cross section and a square shaped hollowness. The sides are slightly concave. The hollowness ranges from 5 to 30%. The yarn described in US 2003/039827 may impart color strength and/or a glitter effect to the carpet made therefrom. Furthermore, this document discloses a spinneret plate, which has a cluster of four orifices centered about the central point. Each orifice includes a generally isosceles-triangle-shaped major portion from which extends a pair of legs, each leg of one orifice being spaced from the leg of an adjacent orifice to define a gap. The shape and the angels of the orifice of US 2003/039827 are different from the orifice according to the invention. Due to the design of the orifice, it is not feasible to spin a fine fiber having a titer in the range of 4 to 16 dtex.

[0015] CN 206494991 relates to a special -shaped spinneret plate and is formed by four quadrangle hole interval arrangements. The rounded square fiber has a square hollowness. The hollowness is 15 to 18%. The textiles made of the fibers may be windproof and water repellent. Due to the design of the orifice, it is not feasible to spin a fine fiber having a titer in the range of 4 to 16 dtex.

[0016] JP 2932721 relates to a polyester yarn, wherein the fiber seems square shaped and has a polygonal hollow cross section. The hollow part is 10-40%. The polyester yarn may impart the textiles and clothing made therefrom a refreshing feeling and a glittery appearance. The shape and the angels of the orifice of JP 2932721 are different from the orifice according to the invention. Due to the design of the orifice, it is not feasible to spin a fine fiber having a titer in the range of 4 to 16 dtex.

[0017] CN 2883409 discloses a spinneret for spinning hollow fibers with rectangular cross-section. The textiles made of the fibers may be windproof and water repellent. The spinning pore of spinneret is a rectangular body with 1, 2 or 4 slits; the four corners of the rectangular body are composed of two perpendicularly-crossed long slits and an outward extending short slit. The shape and the angels of the orifice of CN 2883409 are different from the orifice according to the invention. Due to the design of the orifice, it is not feasible to spin a fine fiber having a titer in the range of 4 to 16 dtex.

[0018] CN 105714390 discloses a high-softness composite fiber bundle. The composite fiber bundle has a bundle structure which is formed by gathering 100 to 200 monofilament fibers. The interior of each monofilament fiber is in a hollow circular structure. The exterior of each monofilament fiber is a square structural layer. An inward concave arc is arranged on each side of the square structural layer. A water absorbing layer is arranged between the interior and the exterior of each monofilament fiber. Gaps are formed among the monofilament fibers, so that the stagnant air amount of the fibers can be increased. The water absorbing layer is arranged in each monofil-

ament fiber. The shape and the angels of the orifice of CN 105714390 are different from the orifice according to the invention. Due to the design of the orifice, it is not feasible to spin a fine fiber having a titer in the range of 4 to 16 dtex.

[0019] In processes known from the prior art, hollow fibers are formed by passing through one-clot connected orifices.

[0020] The use of the square hollow fibers for tufted nonwoven backing is not described by the prior art.

[0021] Most of tufted nonwoven backings are filaments in round shape. The round shape gives only a single contact point on the edges while the pile yarn is inserted into the backing by needles during the tufting process.

[0022] Currently, a demand can be seen to fibers, which have lighter weight and/or fibers, which increase the contact and friction between filaments and pile yarn. In both cases the maintenance of excellent performance of pile-holding capability at tufting is desired. Therefore, development of fibers meeting the requested increase of the contact and friction between filaments and pile yarn, with improve pile-holding performance is desired.

[0023] Accordingly, it is an object of the invention to provide optimized fibers having both, a lighter weight and an increase in the contact and friction between filaments and pile yarn in order to provide excellent pile-holding performance.

[0024] The problem underlying of the invention is solved by hollow polymeric fibers comprising a tetragonal square shape sectional area.

[0025] The polymeric fibers according to the invention have the following advantages:

- The contact surface between fiber and pile yarn is increased by both hollowness and tetragonal shaped sectional area of the inventive fiber.
- The hollowness of the fiber increases the outer surface of each fiber.
- The tetragonal shaped sectional area of the fiber enlarges the contact from the fiber and the pile yarn.
- The contact surface between pile yarn and inventive fiber is increased by 20 to 60% compared to round fibers.

45 SUMMARY OF THE INVENTION

[0026] The invention relates to hollow polymeric fiber comprising a tetragonal shape sectional area, wherein:

- the four corner points form essentially a square,
- all four edges are straight or concave,
- the fiber has a cross sectional area hollowness ranging from 12 to 25 %.

[0027] In particular, the invention relates to hollow polymeric fiber comprising a tetragonal shape sectional area, wherein:

- the four corner points form essentially a square,
- all four edges are concave or straight,
- the fiber has a cross sectional area hollowness ranging from 12 to 25 %,
- the fiber has a titer in the range of from 4 to 16 dtex.

[0028] The invention also relates to a nonwoven fabric comprising the polymeric fiber as defined above and below.

[0029] The invention also relates to a carpet tile comprising the polymeric fiber as defined above and below.

[0030] The invention also relates to the use of the polymeric fiber as defined above and below for the preparation of nonwoven fabrics.

[0031] The invention also relates to a capillary spinneret orifice comprising a pattern of arranged holes designed to provide polymeric fibers as defined above and below.

DETAILED DESCRIPTION

[0032] In the sense of the invention the term "outer circle r_o " is the minimum circle that completely surrounds the cross sectional area of the fiber.

[0033] The term "fiber" denotes an elongated body, wherein the length dimension is greater than the transverse dimension of width and thickness. Thus, the term "fiber" includes (single) filament, ribbon, strip etc. Fibers are understood to mean staple fibers or continuous fibers referred to as a filament. The fibers may also be combined to form fleeces, in particular bonded fleeces, for nonwoven fabric.

Fibers:

[0034] The polymeric fibers according to the invention have a generally tetragonal shape sectional area, preferably a square shaped sectional area. The area that is formed if each neighbor corner points of the four outer corner points are connected with imaginary lines is essentially a square. Each outer corner point is connected with its two adjacent outer corner points with a straight or concave connecting section. All four outer edges are independently of one another straight or concave. Preferably, the shape of each outer corner resembles an acute angle, or essentially right angle with straight or concave legs. Thus, preferably, the shape of each outer corner resembles an arrow tip, wherein two straight or concave lines start from each arrow tip and are connected with the adjacent arrow tip. In a preferred embodiment, the outer shape of the fiber has a perfect tetragonal shape (straight edges). The hollow polymeric fiber has preferably a diameter of the outer circle of the tetragon in the range of from 10 μm to 100 μm , preferably from 15 μm to 50 μm .

[0035] The fiber has a cross sectional area hollowness ranging from 12 to 25 % based on the total cross sectional area of the fiber. The total cross sectional area of the

fiber is the sum of the cross sectional area of the hollow-ness and the cross sectional area of the remaining fiber.

[0036] Preferably, the fiber has a cross sectional area hollowness ranging from 15 to 20 % based on the total cross sectional area of the fiber.

[0037] The shape of the inner hollowness is not crucial. Thus, the shape of the hollowness may be round shape, oval-shape, triangular shape, tetragonal shape, square shape, T-shape, M-shape, S-shape, Y-shape, or H-shape.

[0038] In a further embodiment the hollowness has a round shape.

[0039] In preferred embodiment the fiber according to the invention has only one single hole.

[0040] The polymeric fiber according to the invention is prepared by melt or solution spinning through spinneret orifices. For melt spinning, a polymer in the molten state can be fed to a spinneret plate, e.g. by means of an extruder. Preferably, one single fiber is formed by 4 slots in the spinneret, wherein the slots are not connected. Thus, one single fiber is formed by the combined plasticized polymer melt exiting the four slots. In other words, the shape of the fiber is formed by four pieces of slots wherein the capillary of the orifices has an arrow tip shape as explain above. By dividing the polymer melt into four partial strands a higher rate of hollowness can be achieved. Preferably, an air flow is injected from four gaps of each side forming the fiber shape. In particular, each slot of the four slots forming one fiber has a shape that resembles an acute angle, or essentially right angle with straight or concave legs. Especially, each of the four slots has the form of an arrow tip. Preferably, the length of the two legs of each slot is in the range of 0.4 to 0.6 mm. Preferably, the width of each leg is in the range of 0.08 to 0.13 mm. The outer circle of the four slots forming a tetragon is preferably in the range of from 0.98 to 1.10 mm, in particular 0.95 to 1.03 mm.

[0041] Preferably, in the process of the invention the fibers exiting the spinneret are subjected to a one step drawing process (stretching process). For the drawing process, e.g. the newly formed fibers exiting the orifices of the spinneret are first passed through a heated zone, where such a temperature is set as can lead to plastic deformation of the fibers. Subsequent to the heated zone there can be a cooling zone. In this zone the temperature of the fibers is lowered to below the glass transition temperature T_g . Cooling can be carried out in various ways known to the skilled person. When the fiber bundle leaves the cooling zone, the bundle's temperature should be low enough that it can be passed over or along rotating or static guiding elements without the fibers or the bundle being permanently deformed. For drawing, the speed of the fibers (the spinning speed) exiting the spinneret orifices and, if present, the heating and the cooling zone is fixed. The speed can be set to a certain value e.g. by passing the fiber bundle several times across one or more godets. The godets can be heated if desired. By stretching and/or drawing the fibers obtain their final mechanical

properties and morphology, in particular their fineness.

[0042] In the one-step drawing process according to the invention the fibers (i.e. the as-spun product) are drawn immediately after the spinning speed has been fixed.

[0043] In a preferred embodiment of the process of the invention the fibers exiting the spinneret are stretched aerodynamically to obtain the desired strength. The filaments obtained in the spinning process can be deposited forming a nonwoven fabric. E.g. the filaments obtained in the spinning process are deposited on a deposit belt on which they come to lie on top of one another.

[0044] In a further preferred embodiment of the process of the invention the spinning process can be performed as melt-blown process in which the melt exiting from the spinnerets is entrained by an air stream at high pressure and high temperature, so that fibers with a low thickness are formed. These fibers can also be deposited to form a nonwoven fabric. This is done primarily on deposit drums.

[0045] It was found that if the fibers are drawn in one step, square hollow fibers with improved design and improved application properties are obtained.

[0046] Preferably, the ratio of the length to the width of the legs of the each slots is in the range of 4 : 1 to 6 : 1, preferably 4.5 : 1 to 5.5 : 1.

[0047] The titer of the fibers can be measured in terms of linear mass density, i.e. the weight of a given length of the fiber. It is preferred that the polymeric fibers according to the invention have a titer in the range of from 4 to 16 dtex (SI-unit: 1 dtex = 1 g/10000 m).

Material of the fibers:

[0048] In principle, the polymeric fibers according to the invention may be formed from any fiber-forming polymers, i.e. polymers that can be converted into a melt or solution that satisfies the conditions of spinnability.

[0049] Thermoplastic polymeric materials may be used in the present invention. In the sense of the invention thermoplastic polymers are those which can be reversibly deformed above a certain temperature, whereby this process can be repeated as often as desired. Below this specific temperature, these are non-deformable substances. The thermoplastic polymeric material must have rheological characteristics suitable for melt spinning. The molecular weight of the polymer must be sufficient to enable entanglement between polymer molecules and yet low enough to be melt-spinnable. For melt spinning, thermoplastic polymers having molecular weights below about 1,000,000 g/mol, preferably from about 5,000 g/mol to about 750,000 g/mol, more preferably from about 10,000 g/mol to about 500,000 g/mol and even more preferably from about 50,000 g/mol to about 400,000 g/mol. The thermoplastic polymeric materials must be able to solidify relatively rapidly, preferably under extensional flow, and form a thermally stable fiber structure, as typically encountered in known processes, such

as a spin draw process for staple fibers or a spunbond continuous fiber process. Preferred polymeric materials include, but are not limited to, polyesters, polyolefines, polyamides, polylactates, halogen-containing polymers, polyacrylates, polyvinyl acetates, polyvinyl alcohols, polycarbonates, polyurethanes, polystyrenes, polyphenylene sulfides, polysulfones, polyoxymethylenes, polyimides copolymers derived thereof and mixtures thereof.

[0050] Suitable polyolefins are selected from polyethylene, polypropylene, poly(1-butene), polyisobutylene, poly(1-pentene), poly(4-methylpent-1-ene), polybutadiene, polyisoprene and polyolefin containing blends. Suitable polyethylenes are selected from HDPE, LDPE, LLDPE, VLDPE; ULDPE and UHMW-PE. Suitable polyolefin blends comprise at least one polyolefin, especially polyethylene, polypropylene or ethylene-propylene-copolymers and at least one different polymer. The different polymer is e.g. selected from graft or copolymers made of polyolefins and α,β -unsaturated carboxylic acids or carboxylic acid anhydrides, polyesters, polycarbonates, polysulfones, polyphenylene sulfides, polystyrenes, polyamides or a mixture of two or more of the mentioned different polymers.

[0051] Suitable halogen-containing fiber-forming polymers are polyvinylchloride (PVC), polyvinylidene chloride (PVDC), polyvinylidene fluoride (PVDF) and polytetrafluoroethylene (PTFE).

[0052] The polymeric fibers according to the invention may also comprise or consist of at least one non-thermoplastic polymeric material. Suitable non-thermoplastic polymeric materials are regenerated cellulose (in particular viscose rayon, lyocell), cotton, wood pulp, etc. and mixtures thereof. The polymeric fibers from non-thermoplastic polymeric material may be produced e.g. by solution or solvent spinning. Regenerated cellulose can be produced by extrusion through capillaries into an acid coagulation bath.

[0053] In particular, the polymer fibers according to the invention comprise a polymer selected from polyolefins, polyesters, polyamides and copolymers and mixtures thereof.

[0054] The polymeric fibers according to the invention can be constructed as mono- or multi-component filaments. A suitable embodiment is a multi-component filament having a polyester, in particular a polyethylene terephthalate, as core material and a copolyester as finger material.

[0055] The polymeric fibers according to the invention are suitable for the formation of fabrics, e.g. nonwovens that can be advantageously used as filters. The filter substrates may consist of single type of filaments or a combination of different type of filaments.

[0056] The polymeric fibers according to the invention are suitable for the formation of fabrics, e.g. nonwovens that can be advantageously used as carpet tiles. The carpet tiles substrates may consist of single type of filaments or a combination of different type of filaments.

[0057] Different types of filaments can be produced in

one step by so called multi-shape spinning by using a spinneret with a combination of orifices having different shapes. Thereby, it is possible to produce multi-layers fabric in one steps. Thus, it is possible to produce filters with different layers, e.g. having a different air permeability. For example, the resulting filter can consist of layers which indirection of the air stream have a gradient from higher to lower air permeability. The invention allows the production of filters that are effective at removing airborne particles and are characterized by a low pressure drop which is retained over long time of application.

[0058] The design of the filaments and the resulting filters can be optimized according to the demanded air flow/air penetration.

[0059] It is possible to combine fibers of different shapes and/or different sizes: e.g.

a) Combination of filaments having the same shape but a different denier value (e.g. 12 and 6 denier), e.g. fibers according to the invention, preferably in a top-down arrangement.

b) Combination of filaments having different shapes, e.g. round shape, oval-shape, triangular shape, tetragonal shape, square shape, T-shape, M-shape, S-shape, Y-shape, or H-shape. E.g. a combination of round fibers and fibers according to the invention, preferably in a top-down arrangement (two layer fabric).

c) Combination of filaments having different shapes, e.g. round shape, oval-shape, triangular shape, tetragonal shape, square shape, T-shape, M-shape, S-shape, Y-shape, or H-shape. E.g. a combination of round fibers and fibers according to the invention and round fibers, preferably in a top-down arrangement (three layer fabric).

d) Combination of filaments having different shapes, e.g. round shape, oval-shape, triangular shape, tetragonal shape, square shape, T-shape, M-shape, S-shape, Y-shape, or H-shape. E.g. a combination of fibers according to the invention and round fibers and fibers according to the invention (three layer fabric).

e) Combination of filaments having different shapes, e.g. fibers according to the invention and shapes selected from triangles, 4-, 5-, 6-, 7-, 8-pointed stars, ellipse, H-shape, double H-shape and combinations thereof in a top-down arrangement (two and multi-layer fabric).

Process:

[0060] The polymeric fibers according to the invention in one embodiment are spunmelt fibers. Melt-spinning in the sense of the invention is a kind of thermoplastic extrusion. Melt-spinning includes spunlaid processes, melt-blown processes and spunbond processes. Those processes are known to a person skilled in the art.

[0061] The first step in producing a fiber is usually a

compounding or mixing step. In the compounding step, the raw materials are heated, typically under shear. The shearing in the presence of heat will result in a homogeneous melt of the thermoplastic material and optional non-thermoplastic material. The obtained melt is then placed in an extruder, where the material is mixed and conveyed through capillaries to form fibers. The fibers are then attenuated and collected. The fibers are preferably substantially continuous (i.e., having a length to diameter ratio greater than about 2500:1), and will be referred to as spunlaid fibers.

[0062] In a preferred embodiment of the process according to the invention, a spinneret is used comprising capillary spinneret orifices forming a pattern of arranged holes designed to provide polymeric fibers as defined above.

[0063] The spinneret comprising a pattern of arranged holes designed to provide polymeric fibers as defined above is also one aspect of the invention.

[0064] In a preferred embodiment the spinneret comprises orifices consisting of four slots, wherein each slot has a shape that resembles an acute angle, or essentially right angle with straight or concave legs (arrow tip).

[0065] The fibers may be converted to fabrics by different bonding methods. In a spunbond or meltblown process, the fibers are consolidated using known industry standard technologies. Typical bonding methods include, but are not limited to, calender (pressure and heat), through-air heat, mechanical entanglement, hydraulic entanglement, needle punching, and chemical bonding and/or resin bonding. For the pressurized heat and through-air heat bonding methods fibers are required that are thermally bondable. The fibers may also be woven together to form sheets of fabric. This bonding technique is a method of mechanical interlocking. The fibrous fabric may then be incorporated into an article.

[0066] Another aspect of the invention is a textile structure, e.g. in the form of woven fabric, knitted fabric, laid scrim, or nonwoven fabric, comprising the polymeric fibers according to the invention. A textile structure in the sense of invention is a combination of fibers or fiber bundles. It can be single or multi-layered. A textile structure in the context of the present invention is defined as woven fabric consisting of at least one layer, preferably more than one layer, single- or multi-layered woven fabric, single- or multi-layered nonwoven fabric single- or multi-layered knitted fabrics, single- or multi-layered laid scrim fabrics, preferably several layers, consisting of parallel fibers, fiber bundles, yarns, twists or ropes, whereby the individual layers of the parallel fibers or fiber bundles of yarns, twists or ropes may be twisted relative to one another, or nonwovens.

[0067] A particular aspect of the invention is a nonwoven fabric comprising the polymeric fibers according to the invention. Therefore, a further aspect of the invention is the use of the polymeric fibers as defined above for the preparation of a nonwoven fabric.

[0068] Nonwoven fabric is also called spunbonded

nonwoven, spunlaid, spunbond or spunbonded fabric.

[0069] Generally, nonwoven fabric are made from fibers of practically unlimited length and are made in one continuous process.

[0070] The nonwoven fabric is preferably obtained by thermal bonding from fibers obtained by meltblowing. Thus, the nonwoven fabric preferably comprises melt-blown polymer fibers, in particular at least one hollow polymer fiber according to the invention. In a special embodiment the nonwoven fabric comprises at least one polymer fiber according to the invention and at least one fiber which is selected from:

- fibers having different denier values compared to the polymeric fiber according to the invention,
- fibers having different shapes compared to the polymeric fiber according to the invention.

[0071] The proportion of fibers according to the invention is preferably 1 to 99% by weight, based on the total weight of the fibers.

[0072] The specific cross-sectional shape of the fibers different from the fiber according to the invention plays a secondary role, provided that under the stated conditions a nep adhesive force with respect to a tuft yarn is achieved in the stated range. Fibers different from the hollow fibers according to the invention having a triangular cross section, referred to as trilobal fibers, fibers having a star shape with four, five, or more arms, or fibers having a flat, oval, T-shaped, M-shaped, S-shaped, Y-shaped, or H-shaped cross section may be used.

[0073] In the technical field of nonwovens, the term "meltblowing" essentially refers to a spinning process, in which thermoplastic fiber forming polymer is melted, pumped through die holes and enters high-speed air streams when leaving the spinning nozzles. The streams of hot air normally exit from the sides of the nozzles, guide the melted polymer streams and lead to formation of very fine filaments. The filaments are deposited on a collector screen, whereby a relatively fine, typically self-bonded nonwoven web is formed. The meltblow process is different from conventional spunlaid technology, in which the emerging polymer fibers are not guided by air streams from nozzles in the spinneret, but normally only drawn onto a conveyor belt by suction.

When the meltblown polymer fibers are collected on a surface below the meltblowing device, the nonwoven is obtained. Subsequently, the nonwoven is thermally bonded to become the nonwoven fabric. The process is a single step process.

[0074] Methods are known in the art how to modify a meltblow process, such that a broader fiber diameter distribution is obtained. For example, this can be achieved by adjusting the air streams, which take up the emerging polymer fibers, such that they are subjected to higher turbulence and strongly swirled. Alternatively, different fiber diameters can be obtained by simultaneous spin-

ning of fibers with different diameters from different spinning devices into a single nonwoven.

[0075] In a preferred embodiment, meltblowing is carried out in a concentric air meltblowing process. As used herein, this term refers to a meltblowing process, in which multiple rows of spinning dies are used, each of which are surrounded by air nozzles. As described in the art, a relatively broad fiber distribution can be obtained accordingly.

[0076] In a preferred embodiment, meltblowing is carried out in a multi row meltblowing process. As described in the art, the fiber diameter distribution can be enhanced in such a multi-row meltblow process, in which a large number of spinning dies are extruded in parallel.

[0077] In a highly preferred embodiment, meltblowing is carried out in a concentric air multi row meltblowing process. In this embodiment, a concentric air meltblow method is carried out as a multirow process. Such a method is especially suited for obtaining a broad fiber diameter distribution.

[0078] A concentric air multi row meltblowing process is typically carried out as follows. The molten polymer and hot air are fed in parallel through a spinneret through an array of multiple dies and nozzles. The emerging polymer fibers are surrounded by concentric nozzles from which hot air is blown. After exit from such die openings, the molten polymer is immediately stretched by hot air from the surrounding nozzle. The overall system creates a high turbulence, such that sections of the fibers are formed having small and large fiber diameters. The fibers are blown onto a collector and swirled. The collector may comprise suction means. The fibers are accumulated on the collector surface to obtain a nonwoven web, which can subsequently be converted into a nonwoven fabric by thermal bonding, if desired. Thus, the nonwoven fabric is prepared in a one step drawing process.

[0079] Alternatively or in addition, multiple (i. e. two, three or more) multi row meltblowing devices can be arranged in parallel for spinning different polymer fibers into the same nonwoven. In such a process, all polymer fibers, which are spun from different devices, are mixed in the process and laid down simultaneously on a single conveyor belt. A nonwoven is obtained comprising the different fibers, which is preferably homogenous. The fiber diameter distribution can be increased by combining of two or more meltblowing devices, which produce different polymer fibers. When two multi-row spinnerets are arranged at a specific angle, the polymer fibers are blown onto a collector to produce hybrid nonwoven webs of two different fiber types which are strongly intermingled.

[0080] Various process modifications are known and described in the art for adjusting the composition and properties of the nonwovens. Each spinneret can be fed by an independent extruder, or both spinnerets can be fed from a single extruder. With independent extruders, two different polymers can be spun onto the collector to produce hybrid nonwoven webs. For example, a polymer having a low melting point can be combined with another

polymer having a higher melting point, such as polyethylene and polyester. When polyethylene and polyester are combined and calendered, polyethylene can be molten at least in part to adhere the polyester fibers to each other; resulting in a high strength of the nonwoven fabric and a small pore size. It is also possible to combine relatively fine fibers meltblown from a first spinneret with relatively coarse fibers spunlaid from a second spinneret. Such a method can be used for obtaining a high fiber diameter variation. Moreover, polymer materials can be combined, which confer specific properties to the nonwoven, for example by combining polymers having a different meltflow index. For example, a first meltblown polymer could have a meltflow index of 600 or less, whereas a second polymer could have a meltflow index of 600 or higher. The higher the meltflow index is, the lower the melt viscosity is. Thus, finer fibers are produced from the polymer which is meltblown having a higher meltflow index, whereas thicker fibers are obtained from the polymer having a lower meltflow index.

[0081] The nonwoven can also be obtained by other production processes, in which two different fiber types are spun in parallel and combined in the same spinning process. For example when a concentric air multi-row meltblowing process is carried out in parallel with a second spinning process, a mixed nonwoven of intermingled fibers can be obtained on a single deposit. For example, a concentric air multi-two meltblowing process can be combined with a conventional meltblowing process, when two spinnerets are applied in parallel for producing polymer fibers. For example, such a method can be adjusted such that relatively fine fibers are added to the emerging nonwoven from the conventional meltblowing process, whereas fibers having a higher diameter are added from the concentric air multi-row meltblowing process.

[0082] In another embodiment, the nonwoven is prepared in a single meltblowing process from two, three or more different types of polymers, which yield two, three or more different types of polymer fibers. Thereby, a nonwoven is obtained comprising two or more different fibers having different structure, polymer composition and/or functional properties. For example, different polymer fibers can be combined by meltblowing from different spinnerets, or from a single spinneret with different feed lines.

[0083] The meltblown nonwoven is thermally bonded to obtain a nonwoven fabric. As known in the art, such thermal bonding can be carried out in a manner such that the basic fiber structure of the nonwoven is maintained at least in part. Thus, heat is applied to an extent that the fibers may not be completely molten, but only softened, such that binding sites are created throughout the nonwoven fabric. Preferably, the basic nonwoven structure is maintained in the thermal bonding step at least in portions of the nonwoven fabric, especially in the interior.

[0084] In another embodiment, the thermal bonding is carried out by calendering. In this standard method, a nonwoven is passed through a pair of calender rolls,

which are typically heated. The conditions of the calendering step are adjusted such that only a partial melting of fibers occurs, such that the nonwoven is thermally bonded to a desired extent. The amount of bonding and bonding strength can be adjusted for example by modifying the speed of the calender rolls, the pressure applied, the distance between the roller nips and the temperature applied. Thereby, it is possible to obtain a degree of thermal bonding such that a desired mechanical strength is obtained, whereby the basic fiber structure, especially in the core of the nonwoven, can essentially be maintained, or at least maintained to a desired degree. Calendering can be carried out over the total surface of the nonwoven, or parts thereof, when the roller surface is patterned. According to the invention, calendering is preferred for thermal bonding, because the mechanical strength of the nonwoven fabric can be increased, whilst the fiber structure of the nonwoven can essentially be maintained.

[0085] Preferably, the nonwoven fabric of the present invention comprises a tuft-backing containing the polymeric fibers according to the invention.

[0086] Preferably, the nonwoven fabric of the present invention comprises a tuft-backing containing a fiber composition comprising at least one of the polymeric fiber according to the invention and at least one of the fiber which is selected from:

- fibers having different denier values compared to the polymeric fiber according to the invention,
- fibers having different shapes compared to the polymeric fiber according to the invention.

An aspect of the invention is the use of the polymeric fibers as defined above for the preparation of a nonwoven fabric.

[0087] A method for the preparation of a nonwoven fabric, wherein fibers are employed comprising at least one hollow polymeric fiber according to the invention or a fiber composition according to the invention.

[0088] Preferably, the nonwoven fabric is prepared by melt or solution spinning of the fibers through a spinneret comprising a pattern of orifices, wherein one single fiber is formed by passing the polymer melt through an arrangement of four slots, wherein each slot of the four slots forming one fiber has a shape that resembles an acute angle, or essentially right angle with straight or concave legs, preferably each of the four slots has the form of an arrow tip.

[0089] Preferably, the nonwoven fabric is prepared by melt or solution spinning of the fibers through a spinneret comprising a pattern of orifices, wherein one single fiber is formed by passing the polymer melt through an arrangement of four slots, wherein each slot of the four slots forming one fiber has a shape that resembles an acute angle, or essentially right angle with straight or concave legs, preferably each of the four slots has the form of an arrow tip, wherein the fibers exiting the spinneret are subjected to a one step drawing process.

[0090] A further aspect of the invention is the preparation of a tufted nonwoven fabric, wherein the fibers for tufts in tuft backing comprise at least one hollow polymeric fiber according to the invention.

[0091] Another aspect of the invention is a tufted nonwoven fabric prepared by the described method.

[0092] Another aspect of the invention is the use of a tufted nonwoven fabric according to the invention and as defined above as carpet backing for the preparation of carpet.

[0093] The use of a tufted nonwoven fabric according to the invention and as defined above as carpet backing for the manufacture of carpet, wherein the hollow polymeric fibers according to the invention are selected from polyesters and/or polyamides is preferred.

[0094] In one preferred embodiment, the polymeric fibers as defined above can be used for filters and carpets, in particular carpet tiles, wall-to-wall carpets, door mats, throw-in mats, shoe carpets etc. wherein automotive tuft carpets are preferred.

[0095] In the tuft-backing layers of fibers according to the invention are in contact with the pile yarn and fix them to the substrate (tuft backing). It is advantageous of the invention that the contact area between the fibers and the pile yarn is significantly higher than with common round fibers known from prior art.

[0096] It is possible to arrange the fibers according to the invention in the tuft backing that the contact angle between the fiber and the yarn loop (pile yarn) is preferably 20 to 90°, in particular 40 to 90°, especially 60 to 90°.

[0097] A special embodiment of the invention is the use of the polymeric fiber according to the invention as carpet backing and filter.

[0098] A further special embodiment of the invention is a polymer fiber composition comprising at least two different polymer fibers, wherein at least one of the fibers is a polymeric fiber according to the invention as defined above. The afore-mentioned definitions of suitable and preferred fibers according to the invention are fully referred to here.

[0099] The at least two different polymer fibers differ in at least one of the following properties:

- shape of the sectional area,
- titer of the fibers,
- chemical composition of the fibers.

[0100] Preferred are multi-titer, single shape filaments or multi shape filaments.

[0101] In a preferred embodiment, the at least two different polymer fibers are prepared in a single-stage process, in particular using one single spinneret.

[0102] A further embodiment of the invention is a fiber composition comprising at least one of the polymeric fiber according to the invention and defined above and at least one of the fiber which is selected from:

- fibers having different denier values compared to the

polymeric fiber according to the invention and defined above, preferably in a top-down arrangement,

- fibers having different shapes compared to the polymeric fiber according to the invention and defined above, preferably in a top-down arrangement.

[0103] A particular embodiment is a fiber composition comprising at least one hollow polymeric fiber comprising a tetragonal shape sectional area, wherein:

- the four corner points form essentially a square,
- all four edges are concave or straight,
- the fiber has a cross sectional area hollowness ranging from 12 to 25 %

and at least one fiber, which is different from the at least one hollow polymeric fiber.

[0104] In particular, a fiber composition comprising at least one hollow polymeric fiber comprising a tetragonal shape sectional area, wherein:

- the four corner points form essentially a square,
- all four edges are concave or straight,
- the fiber has a cross sectional area hollowness ranging from 12 to 25 %,
- the fiber has a titer in the range of from 4 to 16 dtex,

prepared by melt or solution spinning through a spinneret comprising a pattern of orifices, wherein one single fiber is formed by passing the polymer melt through an arrangement of four slots, wherein each slot of the four slots forming one fiber has a shape that resembles an acute angle, or essentially right angle with straight or concave legs

and at least one fiber, which is different from the at least one hollow polymeric fiber.

[0105] Especially, the fiber composition, comprising at least one hollow polymeric fiber comprising a tetragonal shape sectional area, wherein:

- the four corner points form essentially a square,
- all four edges are concave or straight,
- the fiber has a cross sectional area hollowness ranging from 12 to 25 %

and at least one fiber, which is different from the at least one hollow polymeric fiber, wherein at least one fiber, which is different from the at least one hollow polymeric fiber, is solid.

[0106] In particular, the fiber composition, comprising at least one hollow polymeric fiber comprising a tetragonal shape sectional area, wherein:

- the four corner points form essentially a square,
- all four edges are concave or straight,
- the fiber has a cross sectional area hollowness ranging from 12 to 25 %,

- the fiber has a titer in the range of from 4 to 16 dtex,

prepared by melt or solution spinning through a spinneret comprising a pattern of orifices, wherein one single fiber is formed by passing the polymer melt through an arrangement of four slots, wherein each slot of the four slots forming one fiber has a shape that resembles an acute angle, or essentially right angle with straight or concave legs

and at least one fiber, which is different from the at least one hollow polymeric fiber, wherein at least one fiber, which is different from the at least one hollow polymeric fiber, is solid.

[0107] Especially, a fiber composition, comprising at least one hollow polymeric fiber comprising a tetragonal shape sectional area, wherein:

- the four corner points form essentially a square,
- all four edges are concave or straight,
- the fiber has a cross sectional area hollowness ranging from 12 to 25 %

and at least one of the fiber which is selected from:

- fibers having different denier values compared to the at least one hollow polymeric fiber, preferably in a top-down arrangement,
- fibers having different shapes compared to the at least one hollow polymeric fiber, preferably in a top-down arrangement.

[0108] In particular, fiber composition, comprising at least one hollow polymeric fiber comprising a tetragonal shape sectional area, wherein:

- the four corner points form essentially a square,
- all four edges are concave or straight,
- the fiber has a cross sectional area hollowness ranging from 12 to 25 %,
- the fiber has a titer in the range of from 4 to 16 dtex,

prepared by melt or solution spinning through a spinneret comprising a pattern of orifices, wherein one single fiber is formed by passing the polymer melt through an arrangement of four slots, wherein each slot of the four slots forming one fiber has a shape that resembles an acute angle, or essentially right angle with straight or concave legs

and at least one of the fiber which is selected from:

- fibers having different denier values compared to the at least one hollow polymeric fiber, preferably in a top-down arrangement,
- fibers having different shapes compared to the at least one hollow polymeric fiber, preferably in a top-down arrangement.

[0109] The invention is described in more detail in the following examples.

EXAMPLES

[0110]

Figure 1 illustrates a square hollow polymeric fiber according to the invention.

Figure 2 illustrates a mixture of square hollow polymeric fiber according to the invention and round non-hollow fibers (solid fibers).

Figure 3 illustrates a square hollow polymeric fiber according to the invention.

Figure 4: shows a detailed view of the four slots of spinneret forming a hollow polymeric fiber according to the invention.

Example 1:

[0111] A polyester spunbound fabric (nonwoven fabric) is produced. A special spinneret is used that contains different fiber shapes including square hollow polymeric fiber according to the invention and a metering plate to feed molten polymer to each orifice. The capillary is designated with 4 pieces of each slot in 0.12 mm width and 0.6 mm length and outer diameter 0.99 mm. This yields a good squareness and up to 18% hollowness. A tuft backing is produced by web formation using the obtained fibers, wherein 30% of square hollow fibers are laid vertically right in cross-section. The achieved total surface contact is 40 to 50% higher compared to round-solid filaments.

Example 2:

[0112] A polyester spunbound fabric (nonwoven fabric) is produced. A special spinneret is used that contains different fiber shapes including square hollow polymeric fiber according to the invention and a metering plate to feed molten polymer to each orifice. The capillary is designated with 4 pieces of each slot in 0.11 mm width and 0.6 mm length and outer diameter 1.10 mm. This yields a good squareness and up to 22% hollowness. A tuft backing is produced by web formation using the obtained fibers, wherein 60% of square hollow fibers are laid vertically right in cross-section. The achieved total surface contact is 28.5 to 33.3% higher compared to round-solid filaments.

Claims

1. A hollow polymeric fiber comprising a tetragonal shape sectional area, wherein:
 - the four corner points form essentially a square,
 - all four edges are concave or straight,

- the fiber has a cross sectional area hollowness ranging from 12 to 25 %,
 - the fiber has a titer in the range of from 4 to 16 dtex.
2. The hollow polymeric fiber according to claim 1, wherein the shape of each corner resembles an acute angle, or essentially right angle with straight or concave legs (arrow tip).
 3. The hollow polymeric fiber according to any of the preceding claims, wherein the diameter of the outer circle of the tetragon is in the range of from 10 μm to 100 μm , preferably from 15 μm to 50 μm .
 4. The hollow polymeric fiber according to any of claims 1 to 3, prepared by melt or solution spinning through a spinneret comprising a pattern of orifices, wherein one single fiber is formed by passing the polymer melt through an arrangement of four slots, wherein each slot of the four slots forming one fiber has a shape that resembles an acute angle, or essentially right angle with straight or concave legs, preferably each of the four slots has the form of an arrow tip, preferably prepared by melt or solution spinning through a spinneret comprising a pattern of orifices, wherein the fibers exiting the spinneret are subjected to a one step drawing process.
 5. The hollow polymeric fiber according to claim 4, wherein the length of the two legs of each slot is in the range of 0.4 to 0.6 mm and the width of each leg is in the range of 0.08 to 0.13 mm.
 6. The hollow polymeric fiber according to any of the preceding claims, wherein the ratio of the length to the width of the legs of the each slots is in the range of 4 : 1 to 6 : 1, preferably 4.5 : 1 to 5.5 : 1.
 7. The hollow polymeric fiber according to any of the preceding claims, wherein the fiber is selected from thermoplastic polymers, preferably selected from polyesters, polyolefines, polyamides, polylactates, copolymers derived thereof and mixtures thereof.
 8. A fiber composition comprising at least one of the polymeric fiber as defined in claims 1 to 7 and at least one of the fiber which is selected from:
 - fibers having different denier values compared to the polymeric fiber according to claims 1 to 7, preferably in a top-down arrangement,
 - fibers having different shapes compared to the polymeric fiber according to claims 1 and 7, preferably in a top-down arrangement.
 9. A nonwoven fabric comprising the polymeric fiber as defined in claims 1 to 7 or a fiber composition as defined in claim 8.
 10. A method for the preparation of the nonwoven fabric, wherein fibers are employed comprising at least one hollow polymeric fiber as defined in claims 1 to 7 or a fiber composition as defined in claim 8, preferably wherein the nonwoven fabric is prepared by melt or solution spinning of the fibers through a spinneret comprising a pattern of orifices, wherein one single fiber is formed by passing the polymer melt through an arrangement of four slots, wherein each slot of the four slots forming one fiber has a shape that resembles an acute angle or essentially right angle with straight or concave legs, in particular each of the four slots forming one fiber has the form of an arrow tip, especially wherein the fibers exiting the spinneret are subjected to a one step drawing process.
 11. The nonwoven fabric according to claim 9, in form of a tufted nonwoven fabric.
 12. The nonwoven fabric according to claim 9, comprising a tuft-backing containing the polymeric fiber as defined in claims 1 to 7 or the fiber composition as defined in claim 8.
 13. A carpet tile, comprising the polymeric fiber as defined in claims 1 to 7 or the fiber composition as defined in claim 8.
 14. Use of the polymeric fiber as defined in claims 1 to 7 or the fiber composition as defined in claim 8 for the preparation of a nonwoven fabric, preferably for carpets, in particular carpet tiles, wall-to-wall carpets, door mats, throw-in mats or automotive tuft carpets.
 15. Use according to claim 14, wherein the polymeric fiber according to claims 1 to 7 or the fiber composition as defined in claim 8 is employed as carpet backing.
 16. A spinneret, comprising capillary spinneret orifices, forming a pattern of arranged holes designed to provide polymeric fibers as defined in any of claims 1 to 7, preferably comprising orifices consisting of four slots, wherein each slot has a shape that resembles an acute angle, or essentially right angle with straight or concave legs (arrow tip).

Figure 1:

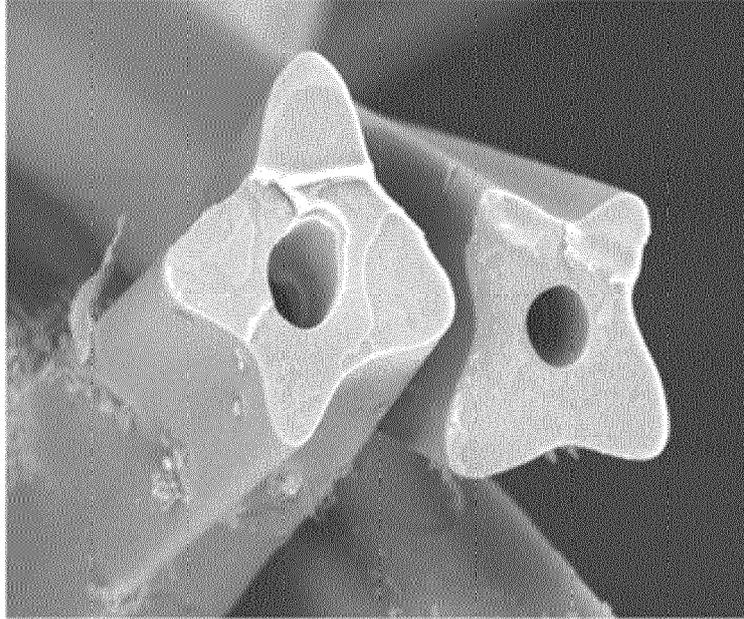


Figure 2:

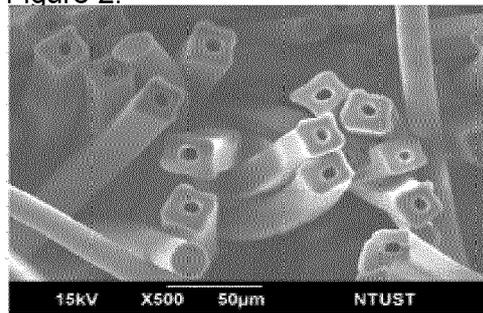


Figure 3

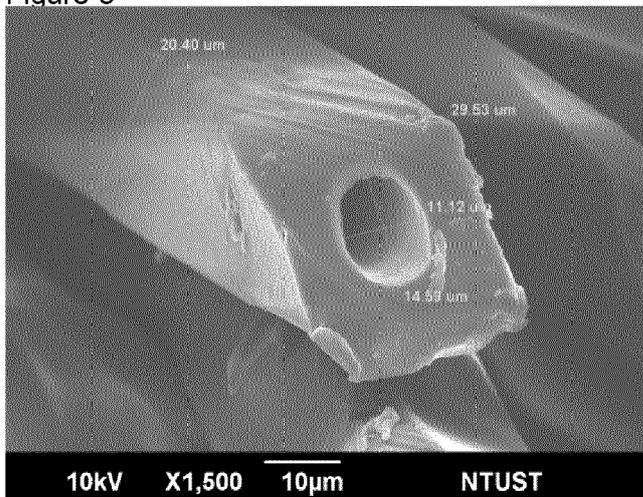
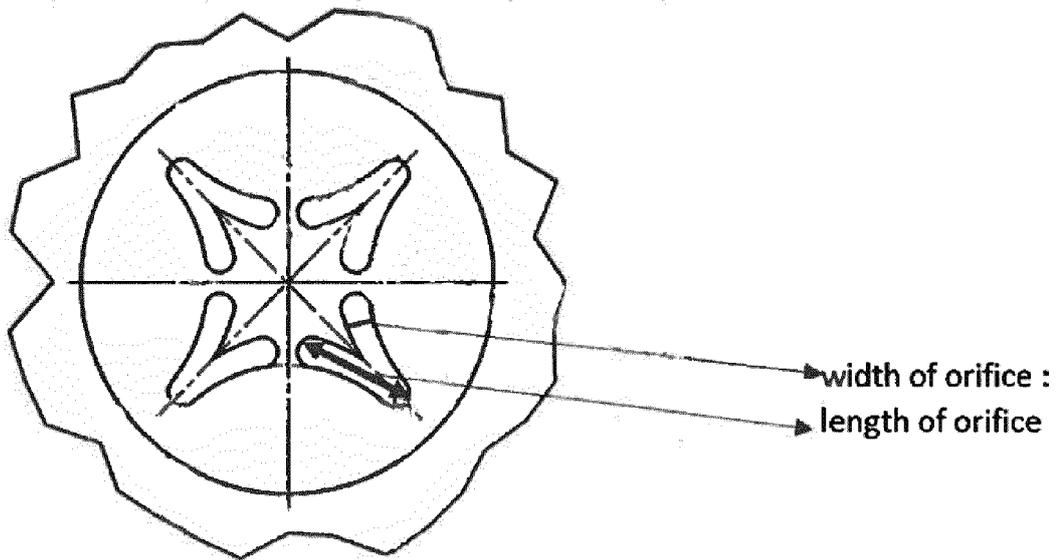


Figure 4:





EUROPEAN SEARCH REPORT

Application Number
EP 21 15 3939

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 18 May 2021	Examiner Malik, Jan
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