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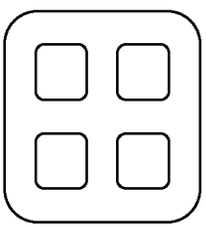
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(54) Square-analogous four-hole hollow staple fiber

(57) The present invention relates to a novel square-analogous staple fiber which is characterized by the four-hole hollow rectangular cross section. The four-hole hollow staple fiber of the present invention has the advantages of the high elastic recovery after water-washing, etc. The said four-hole hollow staple fiber has a fineness of about 2 to about 25 deniers and a hollowness ratio of about 35%. The four-hole hollow staple fiber of the present invention may be used for filling materials, mattresses, filtering materials, non-woven fabrics, etc.

FIG. 2



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Description

BACKGROUND OF THE INVENTION

I. Field of the Invention

[0001] The present invention relates to a hollow cross section synthetic fiber. Particularly, the present invention relates to a square-analogous staple fiber wherein the cross section thereof contains four hollow holes. The said staple fiber has the advantages of high hollowness ratio, high elastic recovery after water-washing, high resilience, high thermal retentivity and higher tension and strength, etc.

II. Descriptions of the Related Arts

[0002] Most synthetic and cellulosic fibers are produced by "extrusion"-forcing a thick, viscous liquid through the tiny orifices of a spinneret to form continuous filaments of semi-solid polymer. The spinnerets used in the production of most fibers are similar, in principle, to a bathroom shower head. A spinneret may have from one to several hundred orifices. As the filaments emerge from the orifices in the spinneret, the liquid polymer is converted first to a rubbery state and then solidified. This process of extrusion and solidification of filaments is called spinning.

[0003] In the early years, the hollow fibers are single-hole fibers. In these days, in order to improve the variety and functional property of fibers, different types of cross sections hollow fibers such as triangular single-hole fibers, multiple-hole (four holes, seven holes, etc.) hollow fibers, multiple-holes circular fibers, etc. are continuously developed.

[0004] For example, EP 0067684A and JP 57-210013A disclose a nonround four-hole hollow crimped polyester fiber having 15 to 35% hollowness ratio. However, in accordance with the said prior arts, only the fibers having near round void cross sections which may be obtained. Moreover, the elastic recovery of the said fiber is not good.

[0005] JP 2003-055838A discloses a polyester fiber, which comprises a small amount of the third component such as polylactic acid, etc., and has 3 to 8 holes and 25 to 60% hollowness ratio. However, during the preparation of the fiber according to the said prior art, a lower spinning temperature is required before spinneret extrusion to, thereby maintaining the multi-hole state. As a result, the defective fraction of the said fiber would be increased. In addition, the design price of the spinneret of the said multi-hole hollow fiber is overly high and the said spinneret is too complex to manage.

[0006] CN 2418139Y discloses a fiber having four-hole round cross section. However, according to the said prior art, only a circular or round-like multi-hole hollow fiber may be obtained. Furthermore, the strength and the elastic recovery of the fabric thereof are unfavorable.

[0007] It is obvious that the in case of the number of the holes of the fiber increases, the manufacture of the fiber is more difficult. In this connection, the design of the spinneret would be overly complex and expensive and therefore the management of the said spinneret is more difficult. Additionally, as a lower spinning temperature is required to maintain the high hollowness ratio of the fiber, the defective fraction of the said fiber would be increased. Furthermore, too many hollow holes are not actually desired for the fiber since the number of the hollow holes of the fiber closely correlates to the fineness of the fiber and the requirements of the fiber product. Moreover, the processing performance and the price of the fiber product should also be considered.

SUMMARY OF THE INVENTION

[0008] The present invention provides a square-analogous staple fiber having four hollow holes. The staple fiber of the present invention shows not only the desired features of the hollow fiber but also excellent spinning properties and elastic recovery after water-washing. Hence, the fiber of the present invention has advantageous competitiveness over the conventional arts.

[0009] The square-analogous staple fiber of the present invention having four hollow holes in the cross section is **characterized in that** the said square-analogous staple fiber fulfills the following requirements:

$1.10 \leq$ shape factor of the cross section of the fiber (A/B) ≤ 1.414

$16\% \leq$ hollowness ratio of the fiber $\leq 35\%$

wherein A represents half of the diagonal length of a cross section of a monofilament, and B represents half of the width of a cross section of a mono filament.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Figure 1 shows the measurement of the shape factor of the cross section of the fiber of the present invention, wherein the shape factor of the cross section is A/B.

Figure 2 shows the cross section of the square-analogous four-hole hollow staple fiber of the present invention.

Figure 3 is a photograph of the cross section of one embodiment of the square-analogous four-hole hollow staple fiber according to the present invention.

Figure 4 shows the exemplified cross section of the spinneret for the preparation of the square-analogous four-hole hollow staple fiber of the present invention.

Figure 5 shows the comparative data of the elastic recovery after water-washing between the fiber of Example 1 of the present invention and the fiber of the Comparative Example 1.

DETAILED DESCRIPTION OF THE INVENTION

[0011] The present invention provides a square-analogous four-hole hollow staple fiber.

[0012] In the present invention, the term "a square-analogous four-hole hollow staple fiber" refers to a staple fiber having a four-hole rectangular or square-analogous cross section, for example, as shown in figures 2 and 3.

[0013] In a preferred embodiment of the present invention, the said square-analogous staple fiber fulfills the following requirements:

$1.10 \leq$ shape factor of the cross section of the fiber (A/B) ≤ 1.414

$16\% \leq$ hollowness ratio of the fiber $\leq 35\%$

wherein A represents half of the diagonal length of a cross section of a monofilament, and B represents half of the width of a cross section of a mono filament.

[0014] In another preferred embodiment, the cross section of the square-analogous hollow staple fiber of the present invention is rectangular. Preferably, the cross section of the staple fiber of the present invention is square.

[0015] In another preferred embodiment, the cross section of the square-analogous hollow staple fiber of the present invention comprises four hollow holes.

[0016] The square-analogous hollow staple fiber of the present invention has the advantages of high hollowness ratio, high elastic recovery after water-washing, high resilience, high thermal retentivity and higher tension and strength, etc. As the cross section of the fiber of the present invention possesses a square-analogous structure, the resilient force is high after the pressure relief from the press or twist of the fiber. Moreover, the inside cross structure thereof increases the resilient force and the recovery of the claimed fiber. Therefore, the said recovery is better than that of the fiber having circular hollow cross section and therefore the resilience of the product of the fiber of the present invention is better than the conventional technologies.

[0017] In another preferred embodiment, the polyesters and the modified polyesters thereof may be used as the raw material of the square-analogous hollow staple fiber of the present invention. Other materials such as polypropylene, Nylon 6, Nylon 66, etc. may also be used.

[0018] In another preferred embodiment, the square-analogous hollow staple fiber of the present invention is **characterized in that** the shape factor of the cross section (A/B) of the said fiber ranges from about 1.10 to about 1.414. Preferably, the shape factor of the cross section of the said fiber is from about 1.16 to about 1.414.

[0019] In another preferred embodiment, the square-analogous hollow staple fiber of the present invention is **characterized in that** the hollowness ratio of the staple fiber of the present invention ranges from about 16% to about 35%. In case that the hollowness ratio of the fiber is greater than 35%, the fiber wall thereof may crack, the defective fraction of the polyester extrusion would be increased, and thus is unfavorable for the spinning process. On the other hand, if the hollowness ratio of the fiber is less than 16%, the hollowness ratio of the fiber is decreased, the bulk of the fiber would be significantly decreased, and the thermal retentivity of the fiber would also be decreased. Preferably, the hollowness ratio of the hollow fibers is in the range of about 20% to about 30%.

[0020] In another preferred embodiment, the fineness of the square-analogous hollow staple fiber of the present invention is greater than about 2 deniers, preferably from about 3 to about 25 deniers and most preferably from about 3 to about 20 deniers.

[0021] In another preferred embodiment, the length of the square-analogous hollow staple fiber of the present invention, which generally covers all the lengths of the staple fibers, ranges from about 22 to about 100 mm, preferably from about 38 to about 90 mm.

[0022] In another preferred embodiment, the crimp number of the square-analogous hollow staple fiber of the present invention ranges from 4 to 10 per 25 mm.

[0023] In another preferred embodiment, the crimps of the square-analogous hollow staple fiber of the present invention may be helical crimps.

[0024] In another preferred embodiment, the crimps of the square-analogous hollow staple fiber of the present invention

may be saw tooth crimps.

[0025] In another preferred embodiment, the pressure recovery of the square-analogous hollow staple fiber of the present invention is greater than about 90%.

[0026] The square-analogous hollow staple fiber of the present invention may be produced by the process comprising the steps of melting and extruding the polymer, such as PET, through a four-hole hollow spinneret to form filaments; cooling and solidifying the filaments; drawing and thermosetting the filaments; finishing and crimping the filaments; cutting the filaments to desired length; drying and packaging the filaments.

[0027] When synthetic filaments are melt-spun from a polymer melt using a spinneret with a plurality of orifices, a plurality of strand-like filaments are extruded from the spinneret. The filament strands coming out of the spinnerets must be cooled and solidified before being taken up in the form of threads or thread bundles after further treatment. In one embodiment of the present invention, the cooling medium is preferably air, which flows from various angles such as perpendicularly or in parallel to the thread direction and is trained onto the filaments.

[0028] The purpose of the draw process is to convert relatively weak spun fibers to those with greater molecular orientation and the resulting greater strength. In one embodiment of the present invention, the square-analogous hollow staple fiber of the present invention may be drawn by a fiber draw stand to desired deniers.

[0029] As the drawn fiber may shrink after heating, a thermosetting step is required to eliminate the residual stress within the fiber, to accelerate the crystallization of the fiber and to improve the stability of the fiber. In one embodiment of the present invention, a thermosetting roller may be used for the thermosetting step wherein a high-pressure vapor is ventilated and then the treated fibers are cooled by a cooling roller to room temperature.

[0030] The crimping step is carried out to increase the fiber cohesion and improve the hand feeling thereof. In one embodiment of the present invention, the fiber of the present invention may pass through a dancing roller to maintain a constant tension and then pass into a crimper to crimp the fiber.

[0031] The length of the staple fiber depends on the kinds of the fiber. In an embodiment of the present invention, square-analogous four-hole hollow staple fiber of the present invention may be cut by a cutter and, as exemplified above, they ranges from about 22 to about 100 mm, preferably from about 38 to about 90 mm.

[0032] The size and shape of the spinneret holes determine the filament's cross sectional shape. In a preferred embodiment, the square-analogous four-hole hollow staple fiber of the present invention may be obtained by a spinneret having 4 sets of T-shaped slits, for example, as shown in figure 4.

[0033] The square-analogous hollow staple fiber of the present invention, for example, may be used as the material of air filtration, sanitary articles such as diapers, wipers, etc., sleeping accommodations such as mattresses, etc., packaging, building engineering, soil-water conservation, etc.

[0034] The following examples further illustrate the present invention, but it is understood that the invention is not limited thereto. Moreover, it should be indicated that although the numbers and parameters in broader extent are close values, they are accurately recorded in the specific examples as possible.

EXAMPLES

[0035] In the present invention, the physical properties of the products prepared by the examples and comparative examples are determined and evaluated in accordance with the following methods:

1. Test for the Fineness of Fibers:

[0036] After the sampling of 5 bundles of the fiber wherein the said fiber is 0.5g per bundle (please note that hands should be kept dry during the sampling), card those fiber bundles by a carding machine, thereby the said carded fiber bundles are put onto a velour plate and 5 groups of the said fiber are taken by a clip wherein each group contains 50 fibers. The said fiber samples are weighed by a microbalance.

Calculation:

[0037]

(a) Denier

$$\text{Denier} = (9000 \times g) / (L \times 50)$$

2. Measurement of Shape Factor Holding Rate of the Cross section:

[0038] The cross section of a monofilament is taken a photograph by using an optical microscope at a magnification of 400 times, thereby measure the 1/2 diagonal length of a monofilament with squared cross section (i.e., A) and 1/2 width of a monofilament with squared cross section (i.e., B). The shape factor holding rate thereof is measured and calculated by an average value according to the following equation:

$$\text{Shape Factor Holding Rate} = A/B$$

3. Test for the Hollowness ratio

[0039] The cross section of a monofilament is taken a photograph by using an optical microscope at a magnification of 400 times and then measure 20 groups of the total areas of the voids of filaments and the cross section of a monofilament, thereby calculate the average of the ratios thereof.

4. Test for the Compression Rate and Compression Recovery

[0040]

(1) The carded fibers are cut to 10 cm x 10 cm squares and are weighed to 10±1 g.
(2) The said cut fibers are put into testing acrylic plates and an acrylic cover of 50 g is placed thereon.
(3)

Step (a): place a weight of 500 g thereon for 10 seconds; and
Step (b): remove the said weight of 500 g for 10 seconds.

(4) Repeat steps (a) and (b) for 3 times. After removing the said 500 g-weight for 30 seconds, measure the height A of the four corners of the sample.
(5) Place a weight of 500 g thereon for 30 seconds and then measure the height B of the four corners of the sample.
(6) Remove the said weight and stand for 3 minutes, thereby measure the height C of the four corners of the sample.

Calculation:

[0041]

$$\text{Compression Rate (\%)} = (A-B)/A \times 100$$

$$\text{Compression Recovery (\%)} = (C-B)/(A-B) \times 100$$

wherein A is the height of the original fiber, B is the height of the fiber after adding the weight for 30 seconds, and C is the height of the fiber after removing the weight for 30 seconds.

5. Test for the Elastic Recovery After Water-washing

[0042]

(1) After the sampling and carding the fiber of 30 g, the said fiber is placed into a 15 cm x 15 cm container, thereby a 1500 g-weight is placed onto the said fiber for 20 seconds and then measure the recovery height of the fiber in the container.
(2) The said fiber is washed in 50˚C hot water for 10 minutes and then is also placed into the 15 cm x 15 cm container, thereby a 1500 g-weight is placed onto the said fiber for 20 seconds and then measure the recovery height of the fiber in the container.

(3) Repeat the above water-washing steps for ten times.

Example 1:

[0043] The polyester polymer is melted and extruded through a designed four-hole hollow spinneret, the filaments are solidified by cooling at a rate of 40 nm/hr under the cold air supplied, and the filaments are formed at a spinning rate of 700 m/min. After the yarns are drawn at a total drawing ratio of 3.0 times, set those yarns at a temperature of 160˚C, cut the yarns and package them. After the said processes, the four-hole square-analogous hollow staple fiber of 7^dx34 mm may be obtained. The properties of the said fiber are listed in the following Tables 1 and 2.

Example 2:

[0044] The polyester polymer is melted and extruded through a designed four-hole hollow spinneret, the yarns are solidified by cooling at a rate of 40 nm/hr under the cold air supplied, and the filaments are formed. After the yarns are drawn at a total drawing ratio of 3.5 times, set those yarns at a temperature of 160˚C, cut the yarns and package them. After the said processes, the four-hole square-analogous hollow staple fiber of 7^dx64 mm may be obtained.

Comparative Example 1:

[0045] In accordance with the same procedures of Example 1, a round hollow spinneret is used to extrude the melt polyester polymer and a single-hole synthetic hollow staple fiber of 7^dx34 mm may be obtained. The properties of the said fiber are listed in the following Tables 1 and 2.

Table 1: Properties of the staple fiber of the present invention and the fiber of the prior art

Items	Example 1	Comparative Example 1
Deniers	7	7
Strength of Fiber	4.3	3.5
Length	34	34
Hollowness ratio	29	30
Crimp Numbers	8	4
Compression Rate	47	45
Compression Recovery	97	85
Cross Section Shape Factor Holding Rate	1.38	1.0
Spinning Property	excellent	fair
Cross section	⊞	◎

Table 2: Comparative Data of the Elastic Recovery After Water-washing

	Times of the Water-washing										
	0	1	2	3	4	5	6	7	8	9	10
Example 1 (the recovery height of the fiber, cm)	11.4	10.7	10.3	9.8	9.5	9.4	9.2	9	8.8	8.6	8.5
Comparative Example 1 (the recovery height of the fiber, cm)	10.3	9.3	8.7	8.2	8.2	8	8	8	7.9	7.5	7.3

[0046] The present invention is illustrated by way of examples for purposes of clarity of understanding, but the examples are not intended to limit the scope of the present invention. It is readily apparent to persons having ordinary knowledge in the art in light of the teachings of the present invention that certain changes and/or modifications may be made thereto without departing from the spirit or scope of the appended claims.

Claims

1. A square-analogous hollow staple fiber with a four-hole cross section, **characterized in that** the said fiber fulfills the following requirements:

   $1.10 \leq$ shape factor of the cross section of the fiber (A/B) ≤ 1.414
   $16\% \leq$ hollowness ratio of the fiber $\leq 35\%$
   wherein A represents half of the diagonal length of a cross section of a monofilament, and B represents half of the width of a cross section of a monofilament.

2. The square-analogous hollow staple fiber as claimed in claim 1, wherein the cross section thereof is rectangular.

3. The square-analogous hollow staple fiber as claimed in claim 2, wherein the cross section thereof is square.

4. The square-analogous hollow staple fiber as claimed in claim 1, wherein the cross section thereof is a rectangular cross section with uniformly distributed four holes.

5. The square-analogous hollow staple fiber as claimed in any of claims 1 to 5, wherein the fineness of a single filament thereof is from about 2 to about 25 deniers.

6. The square-analogous hollow staple fiber as claimed in claim 5, wherein the fineness of a single filament thereof is from about 3 to about 20 deniers.

7. The square-analogous hollow staple fiber as claimed in any of claims 1 to 5, wherein the length of the said staple fiber is from about 22 to about 100 mm.

8. The square-analogous hollow staple fiber as claimed in any of claims 1 to 5, wherein the hollowness ratio is from about 20% to about 30%.

9. The square-analogous hollow staple fiber as claimed in any of claims 1 to 5, wherein the number of crimps of the said staple fiber is from about 4 to about 10 per 25 mm.

10. The square-analogous hollow staple fiber as claimed in any of claims 1 to 5, wherein the crimps of the said staple fiber are helical crimps.

11. The square-analogous hollow staple fiber as claimed in any of claims 1 to 5, wherein the crimps of the said staple fiber are saw tooth crimps.

12. The square-analogous hollow staple fiber as claimed in any of claims 1 to 5, wherein the compression recovery of the said staple fiber is greater than about 90%.

13. The square-analogous hollow staple fiber as claimed in any of claims 1 to 5, wherein the said staple fiber is a polyester staple fiber.

14. A process for preparing the square-analogous hollow staple fiber as claimed in any of claims 1 to 5, which comprises the steps of melting and extruding the polymer through a four-hole hollow spinneret to form filaments, cooling, solidifying, drawing, thermosetting, finishing, crimping, cutting, drying and packaging.

FIG. 1

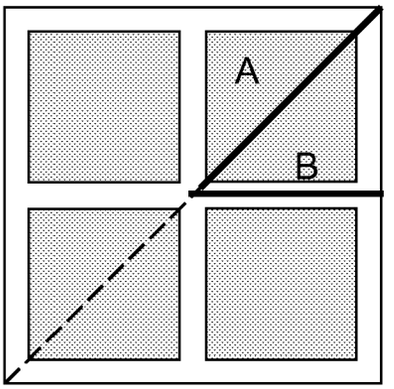


FIG. 2

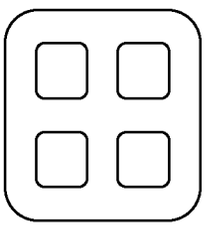


FIG. 3

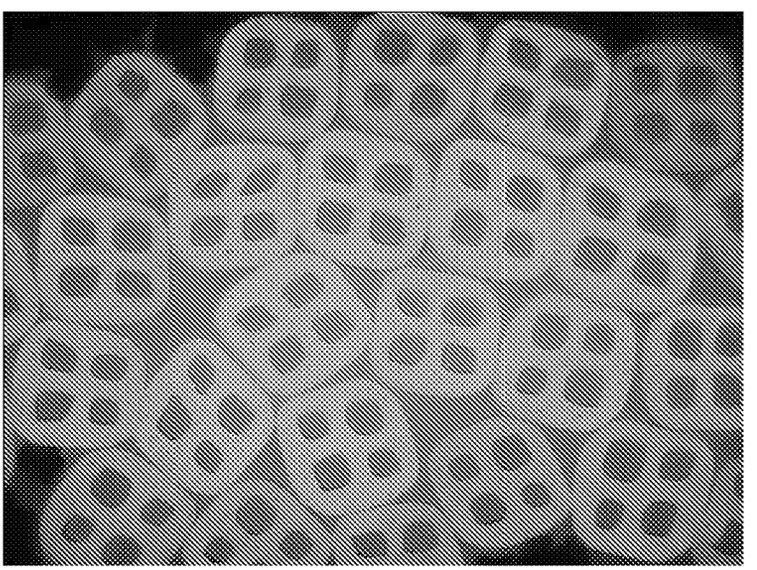


FIG. 4

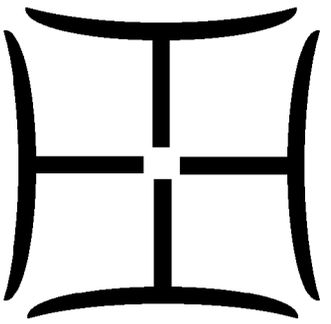
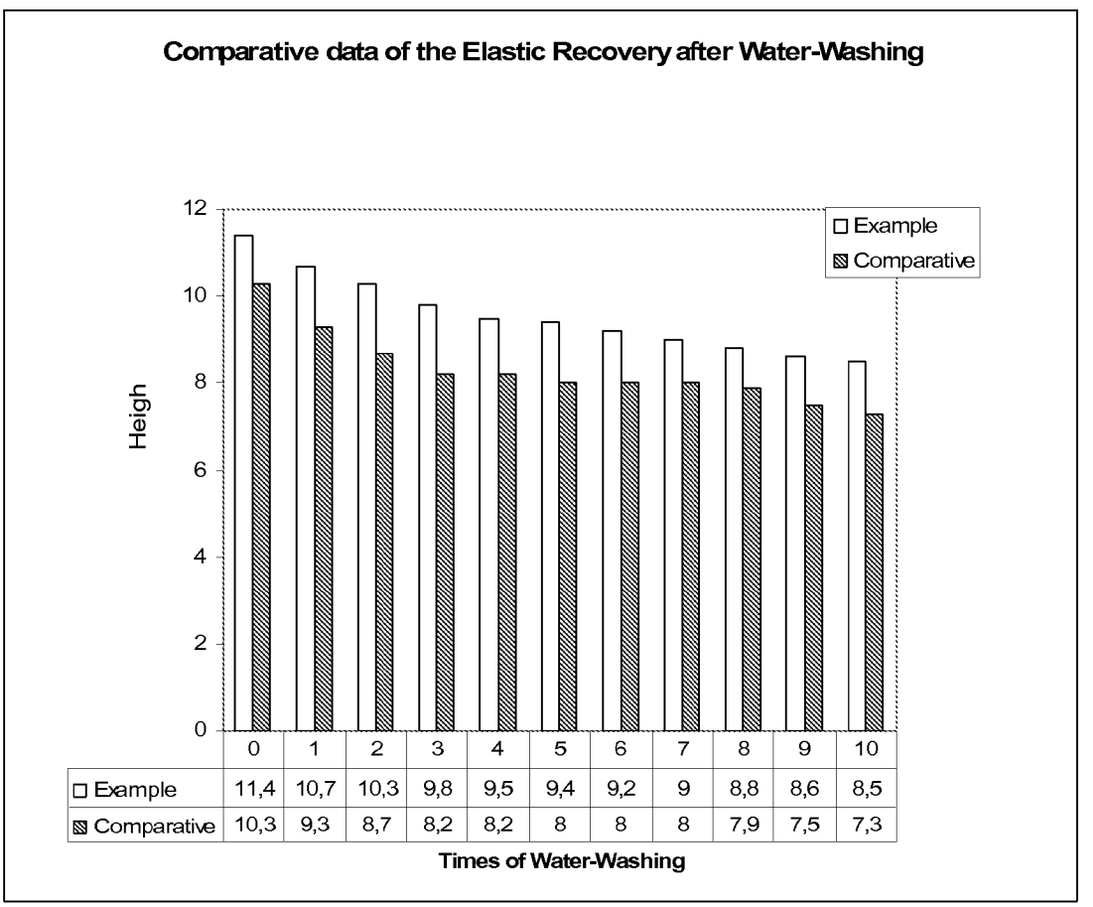


FIG. 5



	0	1	2	3	4	5	6	7	8	9	10
Example	11,4	10,7	10,3	9,8	9,5	9,4	9,2	9	8,8	8,6	8,5
Comparative	10,3	9,3	8,7	8,2	8,2	8	8	8	7,9	7,5	7,3

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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 3464

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	US 2003/096114 A1 (CHEN LIEN-TAI [TW] ET AL) 22 May 2003 (2003-05-22) * the whole document * -----	1-14	

TECHNICAL FIELDS SEARCHED (IPC)

D01D
D01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 April 2009	Lux, Rudolf

CATEGORY OF CITED DOCUMENTS

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1

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2003055838 A **[0005]**
- CN 2418139 Y **[0006]**